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The New Beachy Head Lighthouse.

By T. WILLIAMS.

PEOPLE in general—though few of the readers of an engineering magazine should be among their number—realise very imperfectly the difficulties and dangers involved in the erection of rock lighthouses, for the sufficient reason that the site of those structures is usually so isolated as to be beyond the range of public observation. Thus, to mention only a few of such buildings on the English coast, in connection with their nearest points of land, the Bishop Lighthouse is situated 7 miles from St. Mary's (the chief of the group of Scilly Isles), the Smalls Lighthouse lies 15½ miles from Penman Melyn Point (St. Bride's Bay), the Wolf Lighthouse 8 miles from the Land's End, and the Eddystone Lighthouse 9 miles from Rame Head. It is true that a resident near the shore depôt where are generally stacked the huge blocks of dressed granite intended for a rock lighthouse may form, if he be of an inquisitive habit of mind, some idea, from the elaborate preparations he sees going on there, of the magnitude of the operations at sea; but it will prove a very inadequate conception, after all. No one, however, who peruses such a book as, for example, the life, recently published by Messrs. Longmans, of the late Sir James Douglass, F.R.S., who was one of our greatest lighthouse engineers, and the architect of the present tower on the Eddystone reef, can fail to be impressed with the hardships and perils that are inseparable from this class of work.

Now, the peculiarity of the new Beachy Head Lighthouse which we are about to describe is this, namely, that, while presenting in its erection many of the difficulties and dangers incident to the construction of such buildings situated far out to sea, its site is so little removed from the mainland that the progress of the work could, without much trouble, be watched by the residents of Eastbourne and the numerous summer visitors who throng that pleasant health resort. The enterprise has, therefore, excited a quite exceptional interest for an undertaking of this kind, though even from a strictly engineering point of view, which mainly concerns our readers, it well deserves attention.

There has stood a lighthouse on Belle Toute, the second cliff westward of Beachy Head, since 1834, and from its lantern has been shown a fairly powerful light, though only on the catoptric or reflector system. In consequence, however, of the heavy falls of cliff that had recently occurred in front of and near this structure—about 170,000 tons of material altogether having been thus dislodged—the Corporation of Trinity House, an ancient but still vigorous

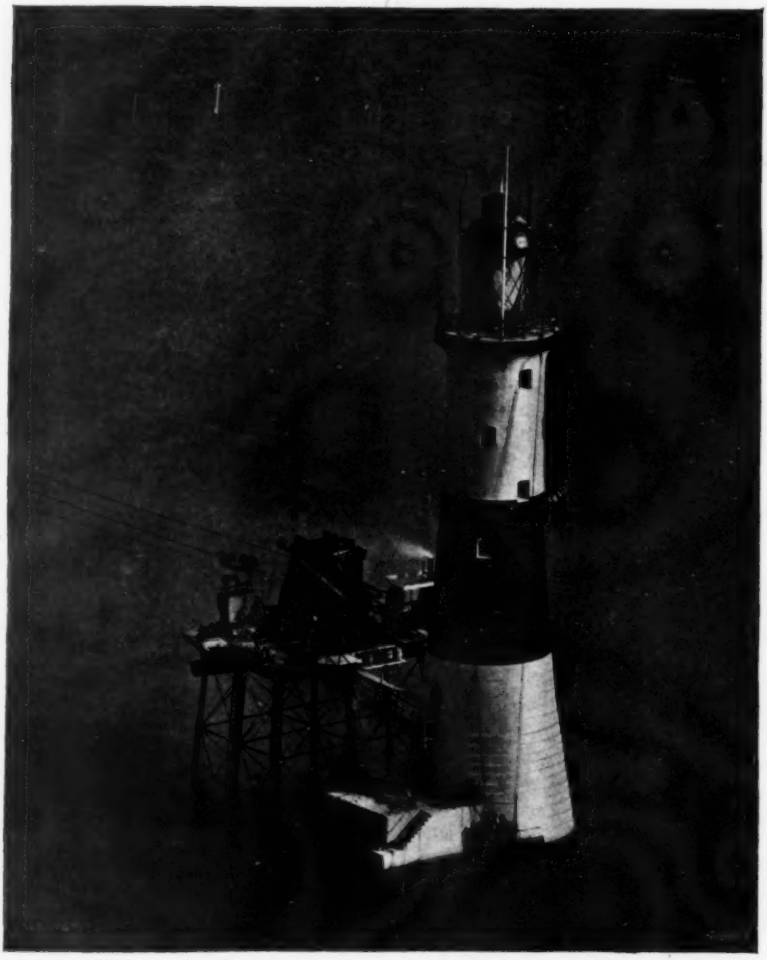


Photo by J. Weston & Son, [*Eastbourne.*

LIGHTHOUSE IN A NEARLY FINISHED CONDITION (TAKEN AT HIGH WATER).

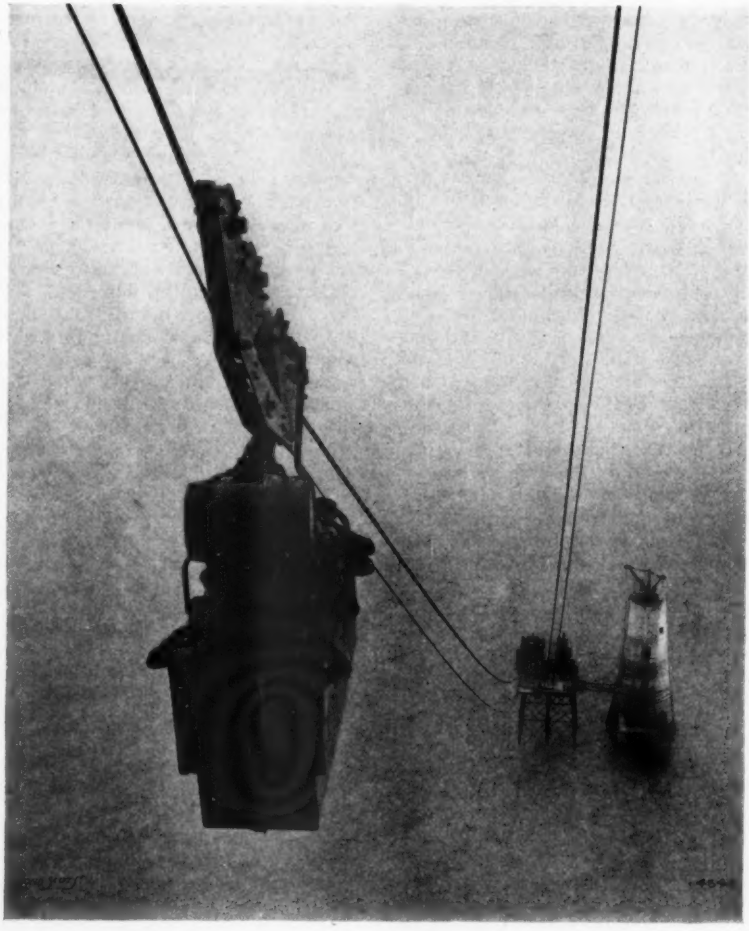


Photo by J. Weston & Son, [*Eastbourne*

WORKMEN RETURNING FROM SEA-STAGING TO WORKYARD.

body, to whom is entrusted the responsible duty of erecting and maintaining the lighthouses on the coasts of England and Wales, determined, a few years ago, to abandon the building and construct in lieu of it, a new one. This latter would, naturally, have been erected on some other and less precarious part of the cliff, had it not been for the fact that at such an altitude—some 430 ft. above high water—there is a much greater prevalence of fog than at a lower level. Now nothing is so bewildering to the mariner as fog, and even the sound signals that are provided for his guidance as accessories to the lights—though these signals have been vastly improved of late years—are, necessarily, but imperfect instruments after all.

In the printed Report, issued in 1901, by the Trinity House Committee, who investigated the subject of fog signals during that year, it is stated, as the result of the elaborate experiments which were carried out by the committee, with the valuable co-operation of Lord Rayleigh, F.R.S., assisted by Mr. Thomas Matthews, the engineer-in-chief to the Trinity House, and its present secretary, Mr. E. Price Edwards: (*a*) "that, from causes which cannot be determined at the time or predicted beforehand, areas sometimes exist in which the sounds from the signal stations may be greatly enfeebled or even lost altogether; and (*b*) that, having regard to the uncertainty attending the hearing of the most powerful sound-signal in all conditions of weather, a fog signal must be regarded as only an auxiliary aid to navigation, which cannot at all times be relied on."

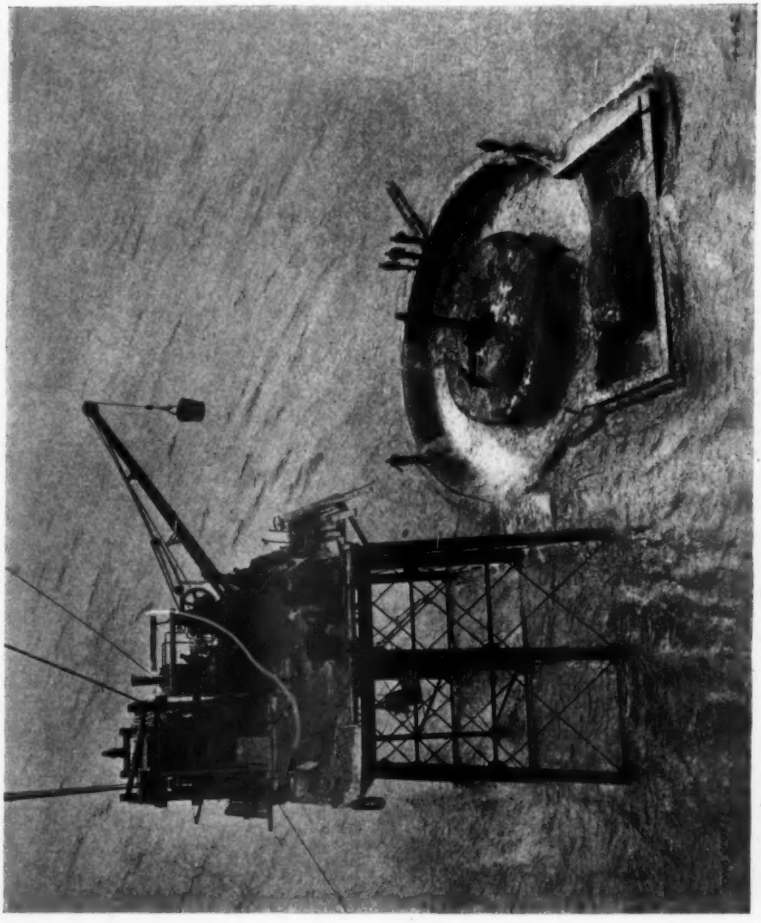
The Trinity House Corporation, having long held the views above expressed, determined, therefore, not to place the new structure at Beachy Head on the headland at all, but on the foreshore below, namely, about 5½ cables from the coastguard flagstaff, in which latter position much less fog prevails than higher up; and thereupon instructed their engineer-in-chief, Mr. Matthews, to prepare plans for a suitable building accordingly. The design submitted by him, and duly approved by his Board, was for a massive granite tower, which was commenced in 1899, and has just been successfully lighted. Tenders for the construction of the building were, in the first instance, obtained from selected firms of contractors; but, all the offers received being much in excess of Mr. Matthews' estimate, the authorities decided to entrust the execution of the work to their own engineer.

With the view of saving as much time as possible during the period of low water, when vessels would not have been able to approach the building site, it was determined to carry on the erecting operations from land, instead of from sea. The use of a sufficient area of ground at the top of the cliff was, therefore, obtained, on a mere nominal payment, from the Duke of Devonshire for the purpose of a work-yard, and the latter was connected with the site of the new lighthouse below,—some six hundred feet out from the foot of the cliff,—by means of a wire ropeway, which was constructed by the well-known specialists in this description of work, Messrs. Bullivant & Co., Ltd., of London. The blocks of granite, weighing about four tons, as well as other material, etc., for the lighthouse, were conveyed by this ropeway to a staging near the site of the new structure; and by the same means the workmen were carried to and from the scene of their labours.

The ropeway was constructed on the principle of the descending load drawing the ascending load up. Two fixed ropes, of 6-in. and 5-in. circumference, with a breaking strain of 120 tons and 100 tons respectively, were stretched parallel to each other from end to end, the ropes terminating above at a massive wooden trestle, and below at an anchorage near the staging. The heavy loads descended on the 6-in. rope, and on the parallel rope was run a balance load which the descending stones drew up; but for lighter loads each rope was used indiscriminately. The brake gear was most effective, one brake strap controlling the load easily, and another serving as a spare one. The ropeway worked very successfully and without accident throughout the progress of the building, and heavier weights were transported by it than had ever before been

handled over so great a span by similar means in this country.

The first operation necessary on the site was the construction of a staging to receive the seaward end of the wire ropeway and



[*Photo by J. Weston & Son, Eastbourne.*

WORKMEN LEAVING FOUNDATIONS AT A RISING TIDE.

form a base of operations for the workmen. The piles of this staging, which was constructed and erected by Messrs. Head, Wrightson & Co., Ltd., of Thornaby-on-Tees, consisted of steel sections riveted together for their entire length, which latter was the same throughout, any difference in the level of the chalk having been adjusted by excavation. The sections were built around and riveted to wrought-iron shoes sunk into the chalk. The main and cross girders were also of steel, and the deck planking was of redwood. This staging was, of course, removed on the completion of the lighthouse. Another

important preliminary item was the construction of a brick-dam, 10 ft. high, so that the executive staff might continue their work on the foundations as long as possible before the incoming tide flooded the entire site. In the excavations, which were sunk to a depth of 9½ ft. below low water, no blasting was permitted, for fear of shaking or splitting the adjoining chalk.

The excavations being completed, the setting of the lowest courses of the lighthouse was proceeded with. The cranes employed in the work were as follows:—namely, a 5-ton steam-goliath was used in the workyard on the summit of the cliff. It had a 40-ft. span, was 20 ft. high to the crab rails, and was capable of lifting and traversing, or lifting and travelling, at

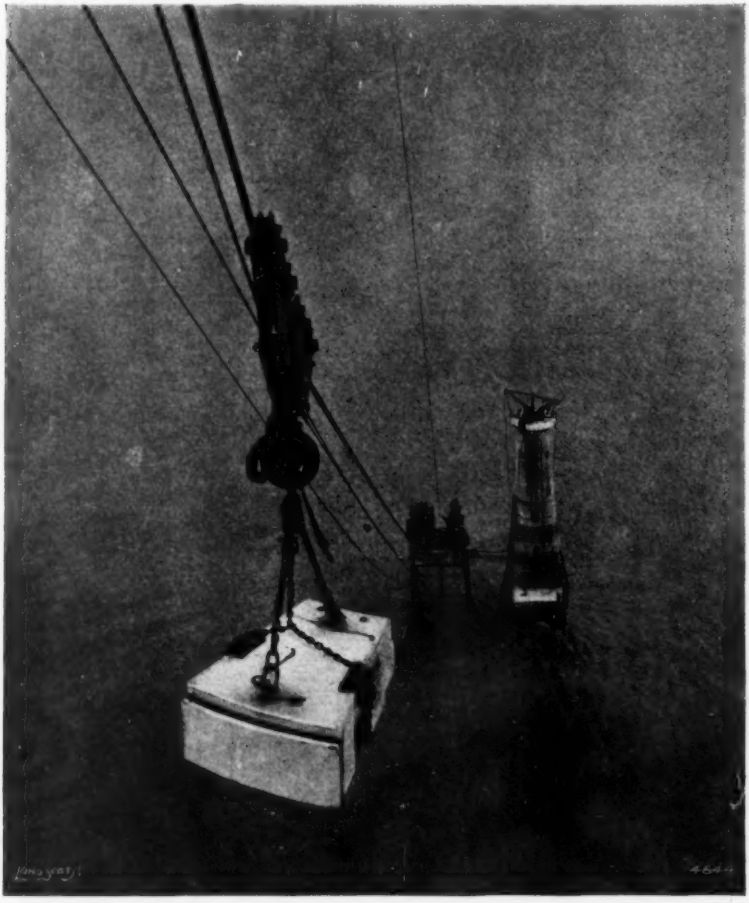


Photo by J. Weston & Son, [*Eastbourne.*

THE LAST STONE OF THE GALLERY PASSING DOWN WIRE ROPEWAY.

the same time with the full load. On the staging below a 5-ton steam-crane was erected, a third crane being fixed in the centre of the lighthouse and lifted as the work proceeded. This last named crane was provided with two jibs, one being used to lay the granite blocks in their places, and the other to raise the stones to the top of the work when the masonry got too high for the crane on the staging to deliver them. These three cranes were supplied by Messrs. Stothert & Pitt, Ltd., of Bath. The base of the tower where let into the chalk is cylindrical in form, 48 ft. 4 ins. in diameter for a height of 9 ft. 4 ins., the shaft of the building above this level being a concave elliptic frustum, the generating curve of which has a semi-transverse axis of 190 ft. and a semi-conjugate axis of 54 ft. The masonry, which was quarried and dressed at the famous De Lank quarries, Cornwall, is of the best fine-grained granite. The stones are dove-tailed both horizontally and vertically, and set in Portland cement, which latter was supplied from the Medway by the Burham Company and Messrs. Hilton Anderson, & Co. The courses were all accurately fitted together, or dry-set in sections, on a trial-platform at the quarries before their removal to Beachy Head, and on being approved, were marked with distinguishing letters on the joints, to facilitate erection. They were then forwarded by rail to Eastbourne, whence they were transported by road to the workyard. The mode of bonding the stones is very effective. Smeaton, in the construction of his famous tower on the Eddystone, employed for this purpose six hundred and thirty-six stone joggles, one thousand eight hundred oak trenails, four thousand five hundred and seventy pairs of oak wedges, eight circular floor-chains, and two hundred and twenty-six iron cramps. The modern approved method, which was invented by the elder Douglass, and has been applied to the Beachy Head lighthouse—as indeed it has been to all English rock lighthouses for the past forty years—consists in having a raised dove-tailed band, 3 ins. in height, on the top bed and one end joint of each stone. A corresponding dove-tailed recess is cut in the bottom bed and end joint of the adjoining stones, with just sufficient clearance for the raised band to enter it freely in setting. The work, when thus put together and set in Portland cement, is nearly as homogeneous as solid granite. This description of joggling, though adding, of course, to the cost of the structure, renders it thoroughly reliable step by step as it proceeds, and thus facilitates the process of construction. By the method adopted each stone is supported, not only by the stones below, but by those beside and behind it, and can, therefore, as soon as set, be left with perfect safety.

The tower is solid for 47½ ft. upwards, with the exception of the space required for the storage of water; and its height to the top of the masonry, which is nearly 20 ft. below the vane, is 123½ ft. Above the solid portion come the rooms, eight in number (the four uppermost ones being 14 ft. in diameter), and finally the lantern and optical apparatus. Access to the tower above the solid portion is effected by means of cleats let into the external masonry, thence through the entrance door; and winding staircases conduct the visitor from room to room. The entrance door, lower window-frames, and shutters are of solid gun-metal, the first named weighing about a ton. The total weight of granite in the structure is about 3,660 tons.

The lantern is of the Douglass steel helically framed type, which, besides being optically perfect in form, and possessing a maximum of strength, offers a minimum of obstruction to the light sent from the illuminating apparatus. The lantern is cylindrical in shape, with a domed roof. Its inside diameter is 14 ft. in the clear of the glass, with a clear height of 10 ft. of glass; its full height being 26 ft. 11 ins. from the base of the pedestal to the centre of the vane. It is glazed with glass ¾ in. thick.

The optical apparatus erected in the lantern is dioptric, of 920 millimètres focal distance. It consists of three groups (each of two lenticular panels complete, with upper and lower prisms) for giving two white flashes, each of ·53 sec. duration, separated by an interval of 2·80 secs., at periods of 20 secs. The circular table

on which the framework of the apparatus revolves is rotated in a mercury-filled trough, and works with great accuracy and but little friction. The height of the focal plane of the apparatus above high water is about 103 ft. Both the lantern and the optical apparatus were constructed by the well-known firm of lighthouse engineers, Messrs. Chance Brothers & Co., Ltd., of Spon Lane, near Birmingham.

The luminary installed in the optical apparatus is a novel one for lighthouse purposes — namely, an incandescent oil-burner. This is a burner which, after many experiments, has been perfected for his service by Mr. Matthews, for vaporising oil on the well-known "Kitson" system, which consists in the oil, when converted into vapour, being passed through a Bunsen burner, the heat from which renders incandescent a Welsbach mantle. The burner consumes paraffin, like other lighthouse burners, though in a much lesser degree—namely, at the rate of only about a pint per hour; while it has a vastly superior illuminating value—namely, about 1,100 candles initial intensity. This power, when transmitted through the optical apparatus at Beachy Head, is, however, augmented to the enormous intensity of over 240,000 candles, whereas the former light there had a power of only 22,000 candles. The new light, which is visible in clear weather for a distance of sixteen miles, shows over the bearings 63 degs. N., 24 degs. W., through west, south, and east, to 84 degs. N., 21 degs. E. To render the tower more distinctive as a day mark—the grey of granite not being a suitable tint for the purpose—the gallery of the structure is coloured black, and a broad black band is also painted around the building at the level of about half its height.

The lighthouse is fitted with an explosive fog-signal which in thick or foggy weather gives one report every ten minutes. The firing jib is fixed on the gallery of the tower, is raised to the firing position as required, and lowered again for recharging, or when the firing has ceased, the explosion being produced by gun-cotton charges, the report of which is very effective.

The building is electrically connected with the Postal Telegraph system.

The erection of this lighthouse, which was completed without loss of life, or any accident of a serious nature, reflects the highest credit upon all who were concerned in the undertaking, from the engineer-in-chief and the resident engineer, Mr. A. Havelock Case, down to the humblest of the executive staff. In the earlier operations especially the men worked day and night, whenever the tides were suitable, often under very trying conditions, being not unfrequently drenched to the skin, half frozen with the cold, and in danger at any moment of being swept off their feet by the inrushing waves. They were, of course, well paid for their labours, and so they deserved to be; for they wrought at their arduous task with a zeal and energy that were beyond all praise. In conclusion, let us hope that the stately edifice may long survive as a monument to its architect and builders, and prove for generations to come, in the familiar words once uttered in reference to a similar structure, "a great holy good, to serve and save humanity."

The Use of a Surveying Instrument in Machine-Shop Practice.

MANY machine shops now have floor surface plates upon which large work is laid out and various machining operations are performed by the use of portable machine tools secured to the plate. The quality of the work produced is largely determined by the accuracy of the laying out, the correctness of the portable tools, and the trueness of the surface plate.

For work having moderate dimensions, scales, squares, beam compasses, and straight-edges can be purchased in the market sufficiently accurate, if used by careful workmen, to meet the average requirements in laying out the work and setting the portable tools; but for work having large dimensions the scales, squares, beam compasses, and straight-edges become quite special, are expensive, and require the utmost care in their manipulation to ensure correct work. Ten-ft. steel squares and beam compasses spanning 25 ft. are not easy tools to make or handle, and the fear that errors might be made in some large work to be undertaken at East Pittsburg led to the consideration of doing away with these abnormal tools and substituting others more easy to manipulate and of a kind to insure accurate results.

The method decided upon has proved so reliable and satisfactory for nearly two years that a description of it may contain some suggestions of benefit to those using surface floor-plates and portable tools. To carry out the method referred to, we shall require a dividing and levelling instrument of somewhat special construction; for mounting the dividing instrument, a centre column (with a taper hole whose axis is exactly perpendicular to the base of the column), a centre gauge, a straight-edge, several specially ruled targets, a surface gauge, and other small tools.

Let us assume that we have a surface floor-plate, suitable portable vertical slotters or planers and portable horizontal drilling and milling machines, and that we are to construct a cast-iron ring of over 20 ft. outside diameter, properly proportioned. This ring is to be made of six similar sections suitably cored and ribbed, and the only operations to be described are the accurate planing of the joints, cutting the keyways, and drilling the holes for the clamping bolts.

Mount one section upon planed cast-iron blocks about 2 ft. thick and fasten securely to the floor-plate, being careful to equalise any warped surfaces found in the casting. The centre column is to be moved about upon the floor-plate until its exact position in relation to the section has been determined by the use of the centering gauge, and the column is then to be securely fastened to the floor-plate, where it should remain until all the operations upon the section have been completed. (See Fig. 4.)

Mount the dividing instrument upon the centre column, and with the telescope determine the correct position for the zero division of the divided circle, to insure equalising the cut at each joint surface, and clamp the circle in this position. The next move is to secure a straight-edge or parallel to the floor-plate in such a position that its front edge is in exact alignment with what is to be one finished joint surface. The location of the straight edge is determined by the dividing instrument and by the use of a special target, which rests upon the top of the straight-edge and has a zero line exactly in alignment with a shoulder which touches the front of the straight-

This paper, although having been recently presented to a meeting of the American Society of Mechanical Engineers, is of such an interesting character, and appeals to so wide a circle of engineers in this country, that it has been deemed worthy of reprinting.—[ED.]

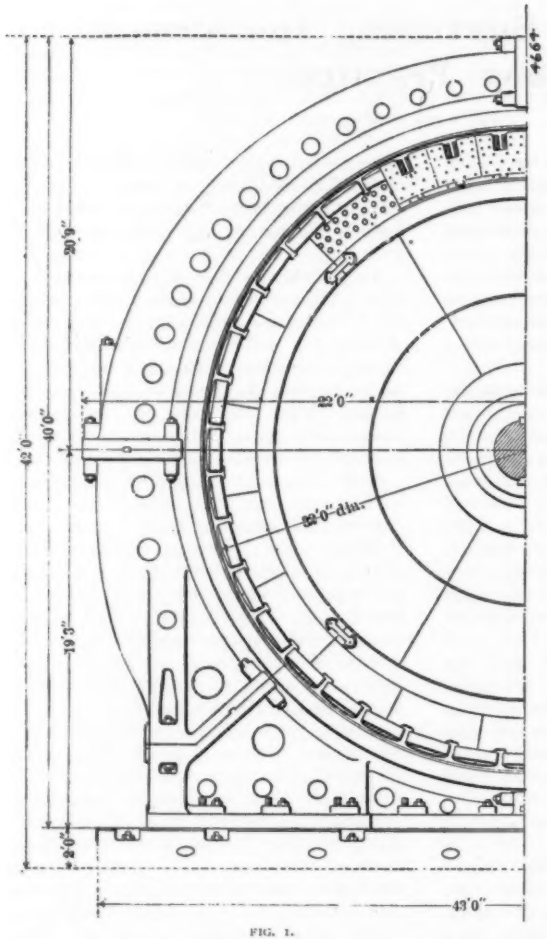


FIG. 1.

edge. (See Fig. 5.) Another straight-edge is then to be secured to the floor-plate under the other joint of the section, and its front edge must be set at exactly 60 degs. from the first straight-edge: its position being determined by the dividing instrument and the special target used in the previous case. The accuracy of the location of both straight-edges being demonstrated by proof surveys, we are ready for planing the joint surfaces.

For the joint-planing operation, let us use a portable vertical slotter or planer having the front edge of its base exactly parallel with the horizontal travel of the tool slide. Secure the portable slotter upon the floor-plate with the front edge of its base exactly parallel to the front edge of the straight-edge, the accuracy of the setting being easily determined by a pin gauge, and the fine adjustment being obtained by screw jacks bearing against the base and stop lugs inserted in the floor-plate. While the roughing cuts are being made upon one joint surface, set a second portable slotter by the other straight-edge in the same manner and proceed with the roughing cuts at this end. In order that the workman while roughing may not cut beyond what should be the finished joint surface it is advisable to scratch a finish line on the rim section at each joint, but the setting of the tool for its finishing cut is more easily and accurately made by use of the telescope of the dividing instrument than by any other plan yet tried.

Before setting the tool for the final finishing cut it may be thought advisable to prove the surface of the last cut—a much simpler matter than at first appears. Let us suppose the last cut has left $\frac{8}{1000}$ in. stock to be removed, and that we have a target with a certain line adjustable in a line parallel with one edge. By resting the edge of the target against the surface, and adjusting its centre line until it exactly cuts the centre of the cross lines of the telescope when set at the correct angle, we can survey the joint surface and prove that it is or is not

parallel with what is to be the finished joint surface. If the surface be found correct, the finishing cut can be made at once; if there be an error, proper adjustment of the portable slotter must be made and the joint surface again surveyed after taking a light cut. The accuracy of the finished joint surface can easily be determined by the dividing instrument with suitable targets.

If the keyway is to be cut parallel with the face of the rim section, the operation can be performed by a portable horizontal milling machine or a portable slotter having a horizontal movement to the tool slide—the correct setting of either machine to be governed by the straight-edge attached to the floor-plate, and the exact vertical location of the keyway determined by a surface gauge.

If the keyway is to be cut parallel with the axis of the rim section, the portable slotter can be used advantageously and the exact distance of the keyway from the centre of the ring determined by a pin gauge calibrating from the tool to a pin inserted in the taper hole of the centre column.

The axes of the bolt holes should be perpendicular to the joint surface, and they can easily be made so if the front edge of the portable horizontal drilling machine be perpendicular to the travel of the spindle and the base of the machine set parallel to the straight-edges attached to the floor-plate. The exact position of each hole is better determined by a jig located by the keyway and a scratched centre line; but if the jig is thought too expensive, the holes can be quite easily laid out in the usual way.

For each of the other five sections the same process should be gone through, and it will be found much easier to adjust the centre column and straight-edges than to attempt to locate each section.

By the aid of the dividing and levelling instrument it is easy to test the accuracy of portable machine tools. In the case of a portable vertical slotter, the vertical travel of the tool slide can be determined by setting the instrument so that the cross lines of the telescope exactly cut a line drawn upon the tool block when at its lowest position. Elevate the tool slide to its highest point, tip the instrument, and note the position of the line on the tool block in relation to the cross line of the telescope. If the tool travel is in a line perpendicular to the base, and the instrument has been properly levelled, there will be no variation in the reading. If the tool travel is not perpendicular the

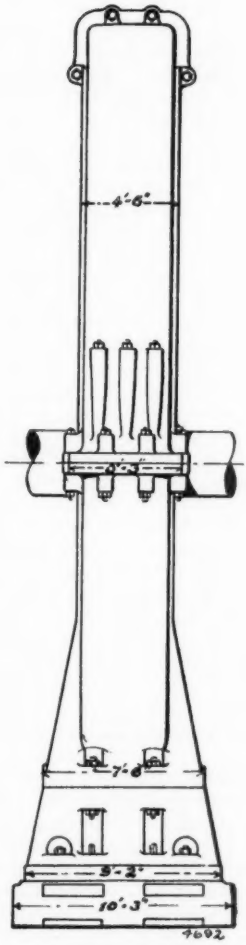


FIG. 2.

instrument indicates the error, and correction can be made in the portable tool itself or shims can be used under the base to correct the error. To test the parallelism of the transverse travel of the tool slide with the front edge of the base of the machine, set the front edge of the base parallel with a straight-edge secured to the floor-plate in a surveyed position—one edge of the straight-edge being approximately perpendicular to the tool slide. Adjust the tool slide until it is exactly perpendicular to the straight-edge by the scratched line as determined by the telescope. A transverse movement of the tool slide to its near and far position will indicate any error; if one be found, it is best to correct the machine by planing or scraping, as may be necessary.

To test the spindle travel of a portable horizontal drilling machine, set the instrument to cut the line of a target attached to the end of the spindle, and survey the spindle in its different horizontal positions. The vertical travel of the spindle slide can be determined by locking the spindle in one position and moving the slide up and down, the same as for testing the slotter. Other portable machines can be tested by similar means, and the result of the tests can be depended upon if the instrument is accurately made and the errors in the subdivisions of the circle are known.

The method described has been practically applied to some of the mechanical operations incident to the manufacture of the eight 5,000-kilowatt alternating-current engine-type 3-phase generators built for the Manhattan Railway Company by the Westinghouse Electric and Manufacturing Company.

The approximate dimensions of some of the principal pieces of one of these generators are shown in Figs. 1 and 2. The extreme height from the bottom of the bed to the top of the yoke is 42 ft., and the greatest horizontal distance over all is 44 ft. The bed plate, 43 ft. long, has two parts, securely keyed and bolted together, each 21 ft. 6 ins. long by 10 ft. 3 ins. wide by 2 ft. thick.

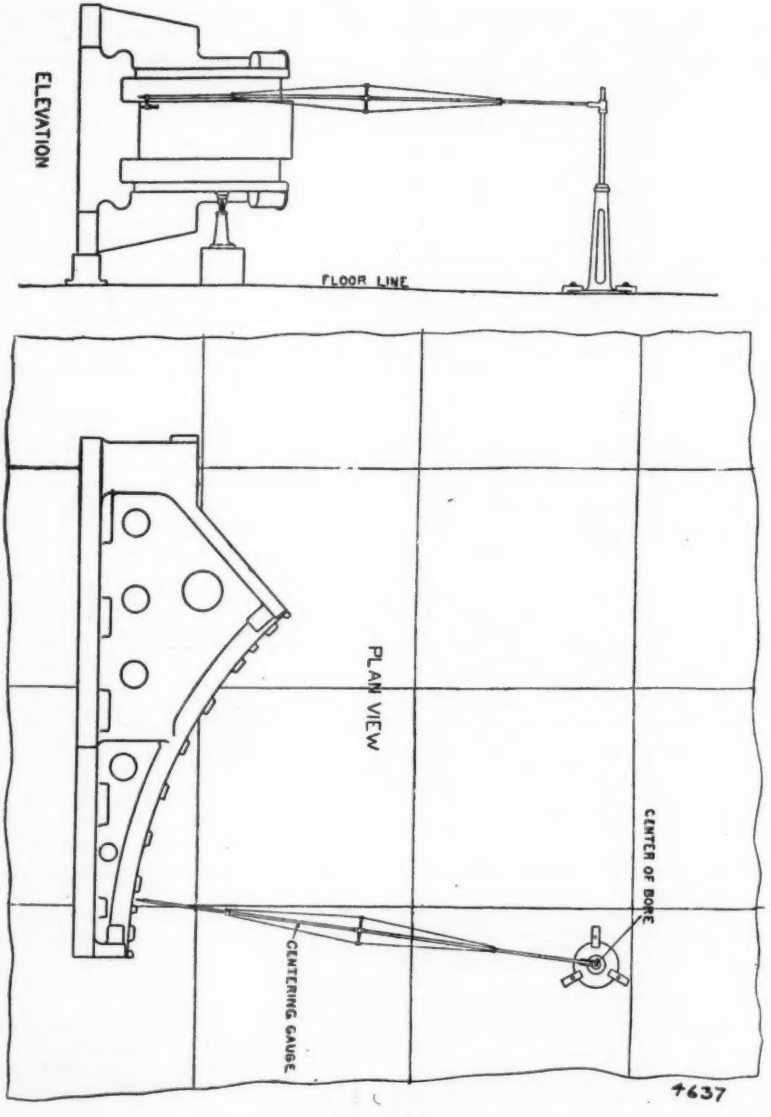
The stationary element, or armature, has six principal sections—two lower, two middle, and two upper — all securely keyed and bolted together; the bore being 34 ft., approximately.

The revolving element, or field, consists of many pieces, the principal ones being the cast-steel hub, the two web plates of six pieces each, and the four ring sections. The diameter of this element is 27 ft. 8 ins. over rim sections, and 32 ft. over all.

The total weight of the stationary and revolving elements of this machine (without the shaft) exceeds 1,000,000 lbs., or 500 tons.

After the preliminary design of these machines had been determined upon, it was apparent that the buildings, travelling cranes, and machine-tool equipment then in service at East Pittsburg were inadequate for the work. A new building was therefore erected, and electric travelling cranes were provided, having ample capacity and mounted on runways of sufficient height to give the crane-bridge the necessary clearance over the top of the generators. It was also apparent, after carefully studying the design, that some of the machining operations could best be performed by the use of portable machine tools, while for others stationary machine tools would do the work more advantageously.

For the operations to be performed by portable tools, and for the erection of the machines, a surface floor-plate was considered a necessity, and the one provided is 48 ft. wide by 176 ft. long; weight, about 2,000,000 lbs. This floor-plate consists of 132 cast-iron sections, each 8 ft. square, of box section heavily ribbed, keyed and bolted together, provision being made for the removal of any broken section should such a mishap occur. The plate, well grouted, rests upon transverse brick piers 12 ft. deep built upon a solid bed of concrete, about 3 ft. 6 ins. thick. The brick piers are 4 ft. apart, centre to centre, tied together at suitable distances by brick arches, and the space between the piers is filled in to within 5 ft. of the under-side of the cast-iron plates. The filling between the piers is covered by a layer of concrete, having enough pitch to properly drain into a longitudinal tunnel at one side of the plate.



FIGS. 3 AND 4.

There are numerous rows of drilled and reamed holes for stop lugs, and tee slots extend the whole length of the floor-plate, with numerous cored holes at the bottom of the slots to permit the chips to fall through into the transverse tunnels. The

longitudinal tunnel has numerous trap doors through which the chips can be taken out, and by a suitable sewer connection it is possible to thoroughly clean, wash, and drain this tunnel whenever necessary.

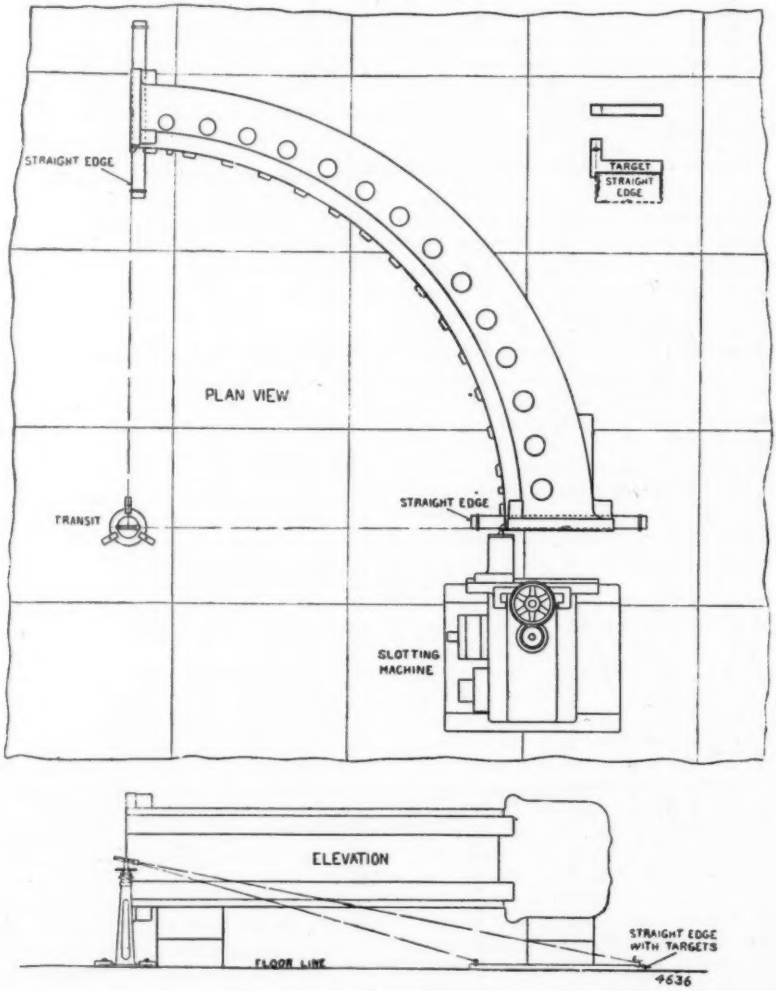


FIG. 5

The principal portable machine tools used were vertical slotters or planers having a stroke of 8 ft., a small horizontal adjustment of the tool slide, a transverse tool travel of 4 ft.—the column having a horizontal adjustment of 4 ft.; horizontal drilling machines having a vertical adjustment of 8 ft., the column a horizontal adjustment

of 4 ft., with spindle travel of 4 ft.; vertical slot milling machines, radial drills, and small vertical slotters.

The principal stationary machine tools were a 14-ft. planer, 8-ft. open-side planer, radial drills with 10-ft. arm, 16-ft. to 24-ft. and 16-ft. to 36-ft. extension vertical boring and turning mills, 28-ft. vertical boring and turning mill, 122-in. engine lathe, a special floor-boring machine carrying portable heads, and several smaller machines.

The bottom and top of bed-plates were planed on the 14-ft. planer, the joint surface and keyway on the open side planer, and the joint bolt holes were drilled on the floor-plate with portable horizontal drilling machines.

The bottom sections were the most difficult to machine, and a more detailed description of some of the operations on these pieces will make it unnecessary to outline so fully the operations on the other sections.

By referring to Fig. 1, it will be noticed that the lower or perpendicular joint is at right angles to, and the upper joint has a portion parallel to, the bottom or base—the remainder of the upper joint being at a definite angle from the lower joint. The rough casting was mounted on the floor-plate, resting on cast-iron blocks, the bottom being set approximately perpendicular to the plate, as shown in Fig. 4.

The proper location of the section involved the making of numerous measurements to insure plenty of stock for finishing—this being particularly necessary for the slot lugs located in the bore. The centre column was mounted on the floor-plate and its position determined by the centring gauge, as shown in Fig. 4—more or less proof testing being necessary to insure its exact location, after which it was securely clamped to the plate.

The perpendicularity of the faces of the slot lugs was determined by scribing lines upon the top surface of the slot lugs with the centre gauge at the proper elevation, and by lowering the centre-gauge rest or support similar lines were scribed on the bottom surfaces of the slot lugs—scale measurements being accurate enough to prove this setting, after which the bottom section was bolted to the floor-plate. The dividing instrument was then mounted upon the column, properly levelled, and finish lines scribed at each joint surface.

Straight-edges were then secured to the floor-plate in their exact position—one edge of each being set exactly perpendicular to the desired finished joint surface,

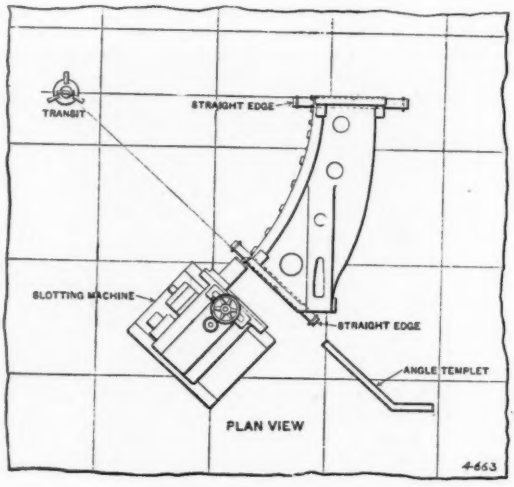


FIG. 6.

the position of these straight-edges being determined by the dividing instrument and suitable target, as shown in Figs. 4, 5, and 6.

After proving the exact position of these straight-edges the portable slotters were set in their correct location, secured to the plate, and the roughing cuts taken, slotters often working upon both joints at the same time. The accuracy of the rough-planed joint surfaces was proved by the dividing instrument and an adjustable target, after which the cutting tool was set by the instrument for the final

longitudinal tunnel has numerous trap doors through which the chips can be taken out, and by a suitable sewer connection it is possible to thoroughly clean, wash, and drain this tunnel whenever necessary.

The principal portable machine tools used were vertical slotters or planers having a stroke of 8 ft., a small horizontal adjustment of the tool slide, a transverse tool travel of 4 ft.—the column having a horizontal adjustment of 4 ft.; horizontal drilling machines having a vertical adjustment of 8 ft., the column a horizontal adjustment

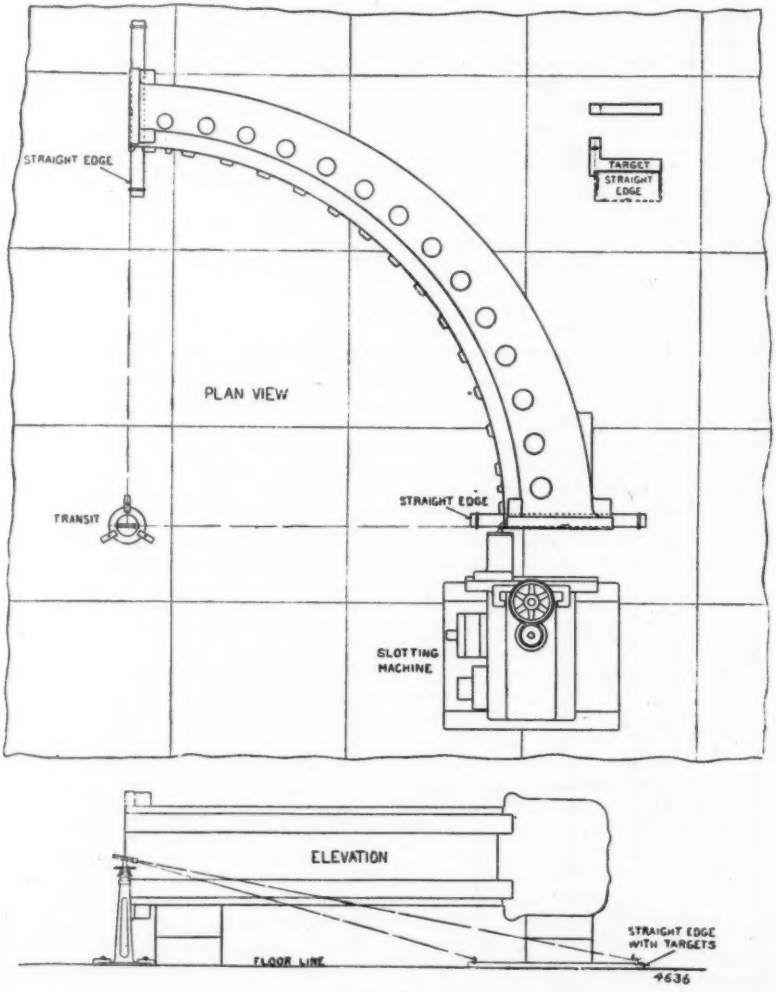


FIG. 5

of 4 ft., with spindle travel of 4 ft.; vertical slot milling machines, radial drills, and small vertical slotters.

The principal stationary machine tools were a 14-ft. planer, 8-ft. open-side planer, radial drills with 10-ft. arm, 16-ft. to 24-ft. and 16-ft. to 36-ft. extension vertical boring and turning mills, 28-ft. vertical boring and turning mill, 122-in. engine lathe, a special floor-boring machine carrying portable heads, and several smaller machines.

The bottom and top of bed-plates were planed on the 14-ft. planer, the joint surface and keyway on the open side planer, and the joint bolt holes were drilled on the floor-plate with portable horizontal drilling machines.

The bottom sections were the most difficult to machine, and a more detailed description of some of the operations on these pieces will make it unnecessary to outline so fully the operations on the other sections.

By referring to Fig. 1, it will be noticed that the lower or perpendicular joint is at right angles to, and the upper joint has a portion parallel to, the bottom or base—the remainder of the upper joint being at a definite angle from the lower joint. The rough casting was mounted on the floor-plate, resting on cast-iron blocks, the bottom being set approximately perpendicular to the plate, as shown in Fig. 4.

The proper location of the section involved the making of numerous measurements to insure plenty of stock for finishing—this being particularly necessary for the slot lugs located in the bore. The centre column was mounted on the floor-plate and its position determined by the centring gauge, as shown in Fig. 4—more or less proof testing being necessary to insure its exact location, after which it was securely clamped to the plate.

The perpendicularity of the faces of the slot lugs was determined by scribing lines upon the top surface of the slot lugs with the centre gauge at the proper elevation, and by lowering the centre-gauge rest or support similar lines were scribed on the bottom surfaces of the slot lugs—scale measurements being accurate enough to prove this setting, after which the bottom section was bolted to the floor-plate. The dividing instrument was then mounted upon the column, properly levelled, and finish lines scribed at each joint surface.

Straight-edges were then secured to the floor-plate in their exact position—one edge of each being set exactly perpendicular to the desired finished joint surface,

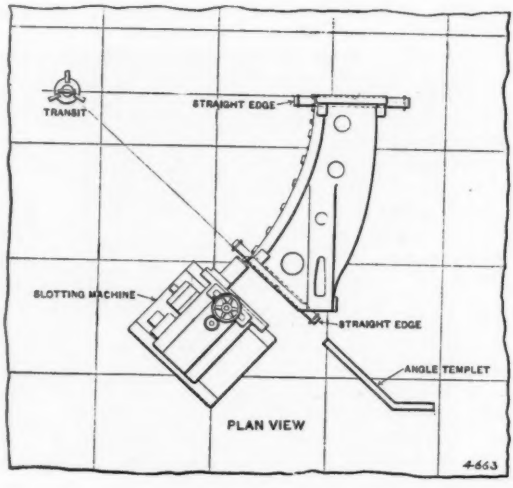


FIG. 6.

the position of these straight-edges being determined by the dividing instrument and suitable target, as shown in Figs. 4, 5, and 6.

After proving the exact position of these straight-edges the portable slotters were set in their correct location, secured to the plate, and the roughing cuts taken, slotters often working upon both joints at the same time. The accuracy of the rough-planed joint surfaces was proved by the dividing instrument and an adjustable target, after which the cutting tool was set by the instrument for the final

radial finishing cut. For that portion of the upper joint of this section parallel to the bottom the slotter was set by the aid of the angle template (shown in Fig. 6), a pin gauge proving that the tool slide was parallel with the angle template.

The joint bolt holes were drilled by the portable drills, the position of the bolt holes being determined by the use of drill jigs located by keys and by a centre line. The drill jigs were made reversible for drilling holes in the faces of the corresponding joint surfaces of the connection sections.

After completing the operations upon the joint surfaces, the lower sections were finished upon the bottom on a stationary planer. The next operation was the drilling of the bolt holes, and the drilling and tapping of the adjusting screw holes in the bottom of the section under radial drills.

The operations upon the joint surfaces of the middle and upper sections were laid out and finished in substantially the same manner as were those on the lower section, some of them being shown in Figs. 5, 6, and 7.

After finishing all the principal operations upon the joints of the six sections the two lower sections were placed in position on the floor-plate, and the lower joint bolted together. The two middle sections were next placed in position and securely bolted to the lower sections. After assembling the two lower and two middle sections of the first generator, it was thought advisable to survey the surfaces of the upper joint of the middle sections to be sure that they were level and in exact alignment with the centre of the machine. These surfaces were found to be so accurate that surveys of the same were not considered necessary on succeeding generators.

One of the upper sections was next placed in position and securely bolted to one of the middle sections. As the joints of the upper section were planned at an angle of 90 degs., and as the bore was 34 ft., the distance from the inner edge of the horizontal joint to the centre was 17 ft. If there were not any deflection the vertical joint would have been exactly in alignment with the vertical joint of the lower section; but it was found that the upper joint overhung $\frac{8}{1000}$ in. in the first generator, and the overhang in the succeeding seven generators in no case exceeded $\frac{11}{1000}$ in. The total variation between the generators, therefore, was $\frac{8}{1000}$ in. The amount of overhang was determined by the use of a plumb-line, the element of the surveying instrument not being sufficient to permit its use.

The second upper section was next placed in position, and first securely bolted to the middle section. After this was done an examination of the upper joint was made, and it was found that a very thin piece of sheet steel could be inserted at the lower edge of the joint while it was tight at the upper edge. When the bolts were put in place and well tightened the joint was absolutely tight all over, and tests with the plumb-line showed the joint to be exactly in alignment with the vertical joint of the lower sections. The variation in the alignment of the vertical joints of eight generators did not exceed $\frac{8}{1000}$ in.

Careful measurements of the vertical diameter were made before the second upper section was put in position, and in every case but two it was found, after placing the second upper section in position, that the tightening of the bolts of the upper vertical joint actually increased the vertical diameter by an appreciable amount, although not exceeding $\frac{8}{1000}$-in. in any instance. This result seemed to prove quite conclusively that no errors had been made in laying out the work or in planing the joint surfaces. It also proved to those responsible for the work that the method was practicable, and that the dividing instrument could be relied upon for accurate results. After assembling the six sections and making proof measurements, the work of chipping the edges of the joints, broaching the sides of the keyways, and fitting the keys was performed. Careful measurements of the horizontal and vertical diameters were recorded, and then the frame was taken apart.

The six sections were next assembled on the special floor-boring machine—the axis of the bore being in a vertical position. The boring machine is 48 ft.

square and has a rotating table over 18 ft. diameter, carrying various portable tool heads, which, for large work, are supported on arms having sufficient radial adjustment to bore up to 40 ft. diameter. The driving mechanism is entirely under the floor, with operating levers at the side of the machine. Current for driving the motors operating the feed mechanism of the portable tool heads is carried up through the centre of the rotating table, where connection can be made by flexible cables.

The assembling of the six sections followed in the order of the first assembling. The lower sections were positioned by a heavy angle-plate securely fastened to the boring machine, which determined the exact distance from the centre to the bottom of the generator. After the sections were properly blocked and bolted together, careful measurements were made of what were the vertical and horizontal diameters when the sections were first assembled. In each case it was found that the former vertical diameter had increased $\frac{1}{100}$-in. and that the horizontal diameter had not changed materially, showing that most of the deflection was in the upper section. By numerous heavy braces and taper wedges the upper sections were sprung toward the centre until the diameter corresponded with the diameter recorded during the first assembling. The frames were then bored, faced, and recessed to the required dimensions. The dovetailed slots for holding the sheet steel laminations were planed and milled—the spacing of these slots being determined by the table of the boring machine.

The table was graduated as follows: In the edge of the table there were 360 holes drilled $\frac{1}{4}$ in. diameter, into which were driven brass plugs. The edge of the table was slightly recessed and the brass plugs faced to protect them from injury. The dividing and levelling instrument was mounted upon a column accurately fitting into a recess in the centre of the table, and a target was set up at quite a distance away. The subdivisions of the circle were obtained by rotating the table until the cross line of the telescope exactly cut the line on the target for each degree—the line then being made on the brass plug by a special graduating fixture attached to the bed of the machine.

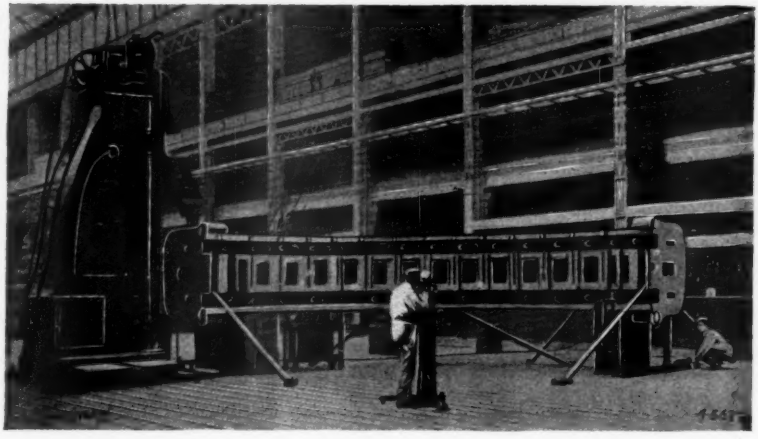


FIG. 7.

After the operations were all performed

on the frame the six sections were taken apart. The sheet-steel laminations, ventilating plates, end plates, and clamping bolts were next assembled with each section of the stationary element.

The end plates for clamping the sheet-steel laminations were made from steel castings and were 35 ft. 4 ins. outside diameter with 16 ins. face. These plates were turned on a 36-ft. extension vertical mill. The end plates were carried on plates mounted upon twelve outriggers bolted to the 14-ft. table of the mill. To these outriggers were attached adjustable shoes resting on an annular bearing 29 ft. diameter, which gave sufficient support to the outriggers and relieved the table of undue strain. The driving mechanism for this mill was the same as in a 16 to 24-ft. extension mill, and was not of sufficient strength to permit of taking heavy cuts.

A worm-gear drive was recently provided, having somewhat unusual sizes. The cast-iron worm gear has 180 teeth, made in 12 sections having 15 teeth each; pitch diameter, 33 ft. 5 ins.; face, 13½ ins. The twelve sections are securely bolted together and bolted to the outriggers. The worm is of cast-iron, 20 ins. diameter, 20 ins. long, 7 ins. pitch, single thread of involute rack-tooth form, 30 degs. included angle. The worm is driven by suitable gearing and runs 30 to 63 revolutions per minute, driving the table one turn in 8¾, 6, 4, and 3 minutes; cutting speeds, at 36 ft. diameter, 13, 19, 28, and 37 ft. per minute.

The dividing and levelling instrument was used only on the rim-section joints and to subdivide the circle for the dovetailed slots. The joints were made by the same means as used for the stationary element sections. The operation of subdividing the circle is shown in Fig. 8, in which the instrument is mounted on a centre column and the lines are ruled on brass plugs by a special graduating device.

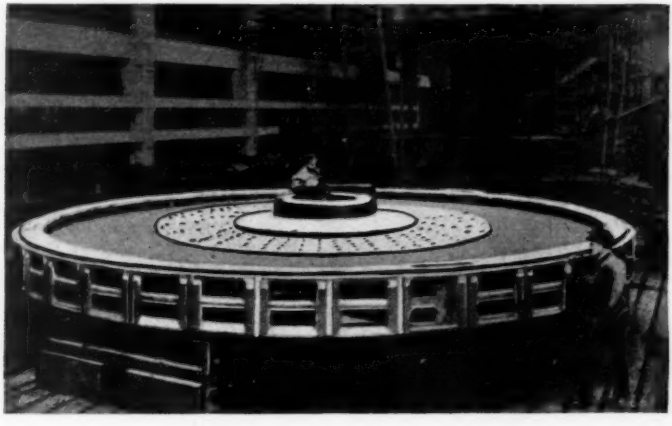


FIG. 8.

The instrument (Fig. 9) in daily use at East Pittsburg was designed and made by The Warner and Swasey Company, of Cleveland, Ohio, who furnished the writer with the following description:

"The knurled base on which the instrument rests is provided with an internal thread for screwing it to the cap of a tripod; or, if it is preferred, a supplementary base can be screwed to it, the latter being provided with a taper hole for readily centring the instrument on a suitably designed cast-iron column. The knurled base has

four levelling screws, by which the body of the instrument is attached, the usual supporting ball and socket joint being provided in the centre between the two.

"In the centre of the instrument are two vertical spindles, the one fitting inside the other. The outer spindle carries the horizontal circle independently from the inner spindle, which carries the supporting yoke and the telescope. The circle is provided with clamps and slow motions, so that its O division can be brought to any position in azimuth and there clamped independently of the telescope. The circle is 12 ins. outside diameter, and is provided with an inlaid silver strip or band $\frac{1}{4}$ in. wide divided into $\frac{1}{6}$ deg. which are read by vernier and reading microscope to 10 secs. The circle has also a second series of graduations, which are read by two opposite microscopes, with a magnifying power of 24, direct to $\frac{1}{10}$ deg.

"The yoke is mounted on the inner spindle and is provided with clamps and slow motions, so that the telescope can be moved to any azimuth position relative to the circle and independently of it. It has 2-min. horizontal levels, 90 degs. apart, for quickly setting the instrument. The telescope rests in a cradle so arranged that it can be revolved about its long or optical axis, the cradle resting in Y bearings which are reversible for collimation, the line of collimation being perfect from a distance of 10 ft. to infinity.

"The telescope has an objective $1\frac{1}{2}$ in. in diameter, a focal length of 11 ins., and gives, with two eye-pieces, magnification of 15 and 22 respectively. The eye-piece has the usual cross wires and focussing adjustment with rack and pinion.

"The cradle trunnion carries a slow-motion arm, which can be clamped at any position for accurate altitude setting. The striding level is $7\frac{1}{2}$ ins. long, has an air chamber and divided scale, $\frac{1}{10}$ in. bubble travel being equivalent to 10 secs. of arc."

Mr. Swasey has stated that the greatest error in the subdivisions of the circle of this instrument would not exceed 1 sec. of arc—an amount equal to 0·3072 in. at a distance of one mile.

So many uses have been found for this instrument, and it has proved so valuable, that a second one was recently ordered to be on hand in case of accidental injury to the one now in service.

FIG. 9.

Nile Irrigation Works.

By W. NOBLE TWELVETREES, M.I.Mech.E.

(Continued from page 152.)

II.—Upper Egypt. *(Continued.)*

At the commencement of the season 1900–1, the foundation work remaining to be done at Asyût was that between the middle of the river and the east bank, and, although of comparatively small length, it proved to be the most difficult portion of the whole work, and preliminary works became necessary, the cost of which was out of all proportion to the result to be attained. The construction of sadds for enclosing the area was begun on January 28, and it was found possible to utilise parts of the old sadds remaining from the previous season's operations. The first enclosure made was near the middle of the river and covered an area of nearly seven acres. It was ready for pumping on March 3, but it transpired on the following day that the sadd at the eastern end of the area was leaky, and inner sadds were then built, by the aid of which a portion of the enclosure was unwatered to a degree sufficient to permit the resumption of masonry work. Unfortunately, the main gap in the foundations could not be completely unwatered, because it was found to be impossible to form a watertight sadd across the finished work of the previous year. Hence it was decided to carry the sadds across the river and to connect them with the eastern bank. These sadds were completed on April 28, but their construction necessitated the complete diversion of the main channel of the river. The total area of the enclosures, which extended nearly half-way across the river, was upwards of 13¼ acres, and 18 pumps were employed for the removal of water. The enclosures were unwatered by May 4; by June 12 the last stone in the foundation was laid, and by June 30 all the remaining piers were carried above the mean level of the river. Simultaneously with the operations described, masonry work was in progress on the other unfinished piers of the barrage, and the arches and superstructure above the piers were commenced.

Owing to the development of numerous springs, especially near the "scar" ends of the foundations previously built, great difficulty was experienced in laying the last section of the foundation. Special measures were adopted to make sure that no voids should exist under the new length of floor, and a large portion of it was therefore drilled with holes through which cement grout was forced down through pipes standing up about 16 ft. above floor level. Before the last piece of foundation was laid, it was discovered that a long length of floor, previously built on the east side, had been undermined by springs. Consequently this had to be grouted up, thus entailing further delay. During the last season of work, 284 springs were encountered, making a total of nearly a thousand since the commencement. By the end of the year 1901, practically the whole of the masonry work was finished, the only part remaining being a portion of the parapet, and in the spring of 1902 the barrage was finally completed.

We now come to the Ibrahimiyeh regulator, a work of practically the same design as the Asyût barrage. The regulator, a portion of which is illustrated in Fig. 18, consists of nine openings, each 16·4 ft. wide, and a lock 27·8 ft. wide, provision being made for the control of water supplies by upper and lower gates, each gate being about 11·5 ft. high. The whole work is con-

structed in Isawiyeh stone, and the superstructure is practically identical with that of the Asyût barrage. For the purpose of affording the necessary facilities for the construction of the regulator, a temporary diversion was made for maintaining the supply of the Ibrahimiyeh canal, this preliminary work being finished by the middle of February, 1901. Sadds were then formed across the existing channel upstream and downstream of the site, and the whole water supply then passed down the temporary channel. About a week later thirteen centrifugal pumps were at work, and immediately the bed of the canal was laid bare the foundations were started. As in the case of the Asyût barrage, numerous springs were encountered, and 116 of these had to be suitably treated. Before the flood arrived work was so far advanced that the temporary diversion could be dammed off, and the flood supply of the canal passed through the regulator and lock. By the end of the same year nearly the whole of the masonry was finished, and only the ironwork was required for the completion of the work.

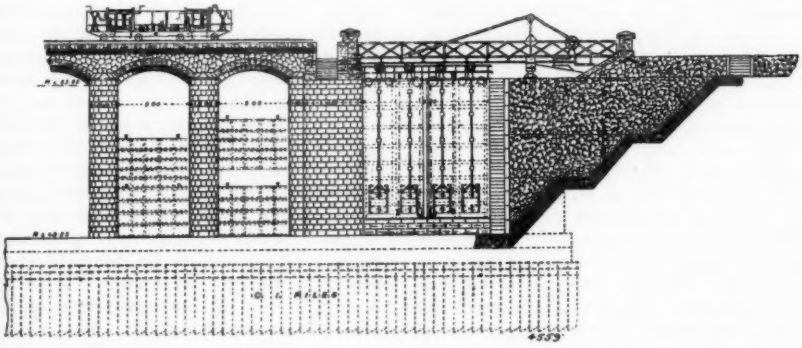


FIG. 18.—IBRAHIMIYEH CANAL HEAD REGULATOR, ASYÛT: UPSTREAM ELEVATION SHOWING SLUICE GATES, TRAVELLING WINCH, AND LOCK GATES.

In concluding this notice of the various works carried out in the vicinity of Asyût, we must mention a very successful piece of river training, the effect of which has proved to be most beneficial to the navigation of the Nile, as well as to the supply of the Ibrahimiyeh canal. It should be explained that for some years past the main channel of the river had been on the east bank, and that a large shoal on the western side had been increasing year by year. Through this shoal a narrow channel was maintained by dredging for the supply of the Ibrahimiyeh canal. After completion of the barrage floor and piers, it was decided to divert the main channel to the opposite side of the river. Accordingly some of the sadds formed for the construction of the barrage were protected with rubble stone, so as to form an obstruction near the east bank of the river during the flood, the theory being that the main channel would thus be forced over to the west side. The result has more than justified the most sanguine expectations, and with the assistance of dredging on the subsidence of the flood, the main channel of the Nile was directed to the desired position. That so great a transformation should have been effected at so small a cost is a matter upon which the engineers may justly be congratulated.

The works at Asyût have been brought to successful completion under the supervision of Mr. A. L. Webb, C.M.G., Director-General of Reservoirs, Mr. G. H. Stephens, C.M.G., having acted as Resident Engineer. Sir Benjamin Baker, K.C.B., was also associated with the works

in the capacity of Consulting Engineer to the Egyptian Government.

Some notice will next be taken of other important works instituted in Upper Egypt by the Irrigation Department within the last two years. One of the chief projects of this kind relates to the development of the West Yusûfi district, and it includes two large regulators on the Bahr Yusûf in Miniyeh Province, one at Nezlet-el-Abid near the boundary of Asyût province, and the other some miles to the north. The two regulators in question are of design generally resembling that of the Asyût barrage, each consisting of 20 openings 9·84 ft. wide, and a navigation lock with lift bridge. These structures are really of sufficient magnitude to merit detailed description, but so much work is being carried out in Egypt at the present time that they must be passed by with a merely incidental reference. Each regulator controls the irrigation of a large tract of country, as previously mentioned in connection with Fig. 14. Another new regulator and lock has also been completed at Mazurah in Miniyeh province, and this is chiefly intended for the improvement of some 30,000 acres of land in the region of Benisuef. Among other masonry works executed may also be mentioned the new Hamad escape in Kench province, a fine solid work of six openings each 9·84 ft. wide; and head regulators for the Kom Badr, Harafsha, Beni Harb, and Soffeiba canals. The floor of a large regulator at Talihat on the Sohagiyeh canal has been completed, this work including 20 openings of 9·84 ft. wide. In addition, a new pumping station is in course of construction at Etsa for the purpose of discharging into the river a portion of the drainage from the "sefi" tracts of Asyût and Miniyeh provinces. The mechanical plant of the station includes four 40-in. centrifugal pumps driven by four compound vertical engines, and is capable of delivering about 6,500,000 gals. of water per hour against a head of 15 ft. The contract for the installation is in the hands of Messrs. Easton & Co. of London, and is to be completed before the flood of the present year. The West Muhit drain has been extended, so that part of the drainage water from the perennial tract of Miniyeh province may be diverted into the Bahr Yusûf. A siphon has been constructed for improving the condition of irrigation in the Hod Walidiyeh, east of the Ibrahimiyeh canal; and a similar siphon has been finished at Mayuna. A reach of the Ibrahimiyeh canal, 10 mls. in length, between Miniyeh and Etsa, is being remodelled, and in connection with this operation a regulator has been built at Hafiz, below the off-take of the Sabakhah canal, which is the main feeder for the Miniyeh basins. A substantial iron bridge has been erected for the Daira Sanieh Railway over the canal; the Miniyeh and Sharana regulators have been remodelled, and four head sluices built for branch canals. In the Fayum province some very comprehensive projects are on foot. The Hassan Wassif canal is an entirely new waterway serving about 110,000 acres of land, and the works carried out, in addition to the excavation of the channel, include a fine head sluice, four road bridges, and a tail escape. Other operations in the Fayum include the remodelling of the Bahr Nezlah and branches, the Tagin drainage system, and the Bahr Seilah; alterations on the Bahr Mitartaris system being also in hand. These are only a few of the results following the able administration of Mr. K. E. Verschoyle, C.M.G., Inspector-General of Irrigation in Upper Egypt.

The Aswân dam, to which attention will now be directed, is the last link in the chain of engineering works provided for the control of the Nile. Before proceeding to give a brief history of this undertaking, and some notes as to its constructional features, it will be convenient to point out the precise nature of the duty for which it was designed. The object of the Egyptian Government was to provide, within Egyptian territory, a reservoir which could always be held in reserve against contingencies, and thus to have comparatively near to the cultivated lands a large volume of water from which supplies could at any time be drawn, and so to protect the more important summer crops from the possibility of extended drought. Fig. 19 is a diagram showing

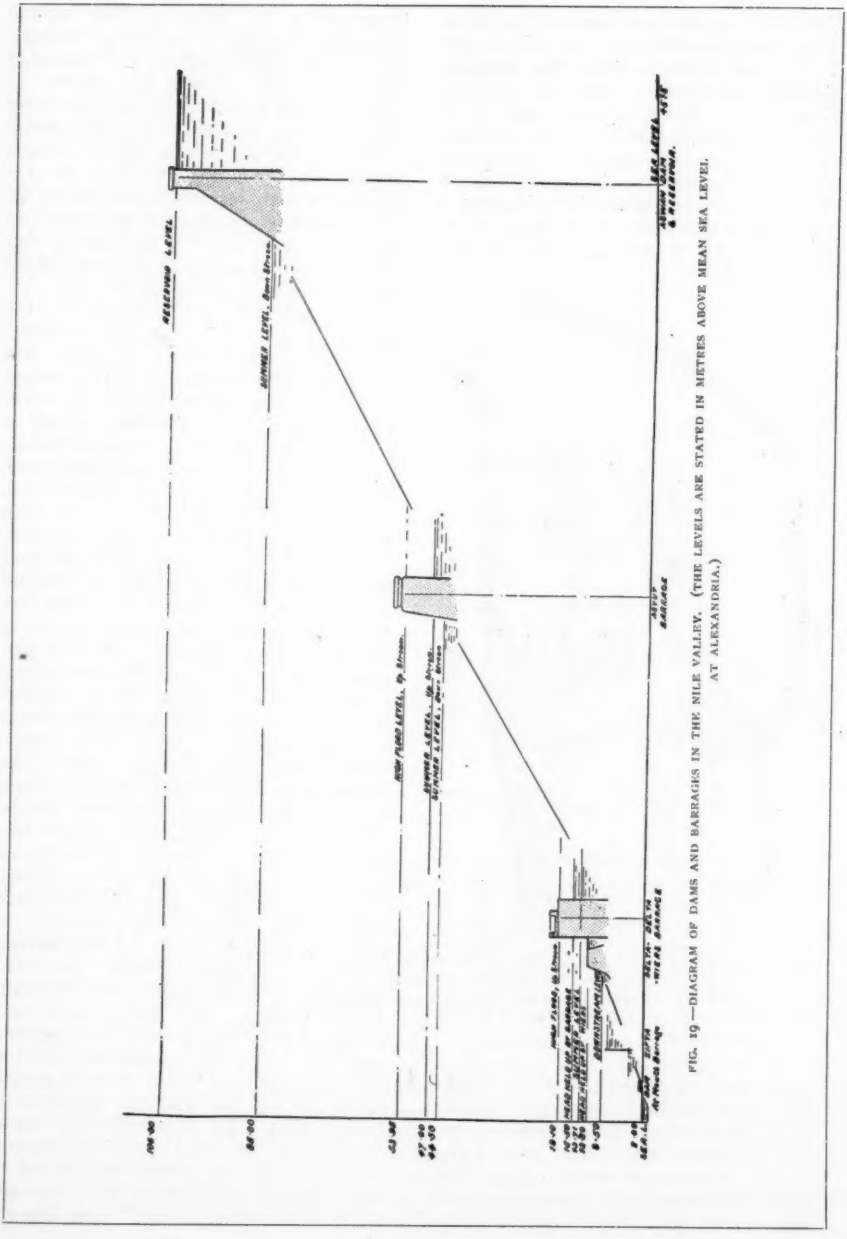


FIG. 19.—DIAGRAM OF DAMS AND BARRAGES IN THE NILE VALLEY. (THE LEVELS ARE STATED IN METRES ABOVE MEAN SEA LEVEL AT ALEXANDRIA.)

the chief regulating works on the Nile, from Aswân to the sea. By this it may be seen that the water of the Nile, formerly flowing unrestrained down the gradual slope of the valley, is now held up at various points for distribution as occasion may demand. At Aswân is the great storage reservoir; at Asyût, a barrage creates a service reservoir which permits the proper apportionment of water, (1) to the lower part of the Nile itself for the supply of certain canals in Upper Egypt, and of all those in Lower Egypt; and (2) to the Ibrahimiyeh Canal, which serves a very extensive area in Upper Egypt, through other great canals. Near Cairo are the celebrated Delta barrage and weirs, impounding water and controlling the irrigation of the Delta; at Zifta, on the Damietta branch, a subsidiary barrage acts in the same way as the combined structures near Cairo; and finally at Damietta and Rosetta there are temporary dams keeping back sea-water, and serving to hold up the river level to about 2 metres above that of the sea. Thus we see at a glance the main features of the scheme by which water is supplied by gravitation to different points, being carried thence over those wonderful networks of canals, which have been already sketched in outline.

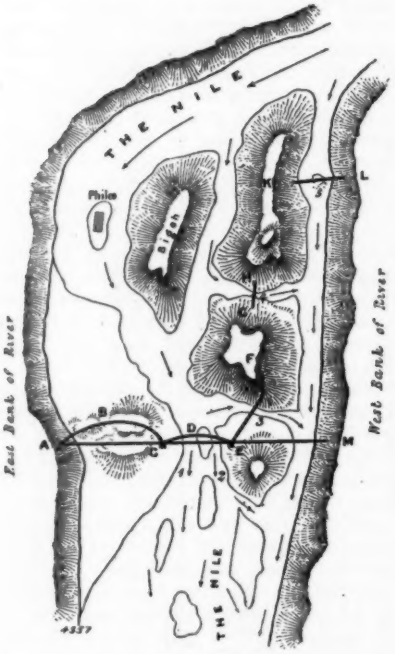


FIG. 30.—SKETCH OF THE ASWÂN CATARACT, SHOWING THE MAIN CHANNELS (1—5) OF THE NILE, THE ALIGNMENT, A, B, C, D, E—L, PROPOSED FOR THE DAM IN 1894, AND THE ALIGNMENT, A, C, E, M, FINALLY ADOPTED.

Ever since Mehemet Ali inaugurated the system of perennial irrigation, reservoirs have been talked about in Egypt, and likely sites have been suggested by various people more or less entitled to be heard. Linant Pasha, the engineering adviser of Mehemet Ali, favoured Gebel-es-Silsileh as the site for a barrage and canal-head. Sir Samuel Baker, the well-known traveller, suggested in 1861 that a dam might be built at Aswân so as to form a large reservoir. Comte de la Motte proposed a dam and reservoir at Gebel-es-Silsileh, to contain 5,580 million tons of water, more than five-and-a-quarter times the present capacity of the new Aswân reservoir. Another proposal, made by Mr. Cope Whitehouse, was to utilise the Wadi Rayan for the creation of a reservoir, the tract in question being a natural depression in the desert immediately south of the Fayûm. None of the foregoing recommendations were favoured, owing to the financial difficulties of the Egyptian Government, and to the fact that it would be useless to construct reservoirs so long as the Delta barrage remained a failure. After that work had been made efficient, the question of reservoirs presented itself for serious consideration. Colonel Western was then authorised to make inquiry into the Wadi Rayan scheme. His report, plans, and estimates were duly printed and carefully put away. After the final completion of the Delta barrage, Sir Colin Scott-Moncrieff again revived the question of reservoir construction. He appointed Mr. (now Sir William) Willcocks as Director-General of Reservoirs, and allotted the period of four years for the purpose of a thorough study of the whole subject. Two reports

were made by Mr. Willcocks, one in 1890 and the other in 1894. In the latter document, perennial irrigation was strongly advocated for Upper Egypt, the works considered necessary were fully described, and the relative merits of five different sites for the establishment of reservoir works were discussed in detail. The Wadi Rayan was shown to be unsuitable, because it could only be of service to Lower Egypt. Gebel-es-Silsileh possessed various disadvantages; a reservoir there would inevitably flood the town of Aswân, as well as various interesting buildings in the valley of the Nile, and the rock was found to be of such character as to render the construction of a dam thereon very inadvisable. Aswân, the site finally selected by the Director-General, appeared to offer many advantages both for the secure foundation of a dam and for the creation of the desired reservoir. The only objection was one of sentimental character, due to the threatened submersion of Philæ Island. Another site immediately above Philæ was found to be unsuitable, the rock being only passably sound, while the river channels were very deep, and did not offer facilities for the economical execution of the necessary works. Kalabsheh, the fifth site, was unsuitable owing to the great depth of the river, and the consequent difficulties and unnecessary cost that would attend the construction of the dam. After considering the different aspects of the general problem, Mr. Willcocks came to the conclusion that no existing type of dam would be suitable for a river which, like the Nile, is subject to turbid floods of long duration. If ordinary methods of construction had been adopted, the ultimate obliteration of the reservoir would have been merely a matter of time. Hence he prepared designs for a dam, with openings capable of discharging the entire flood waters, and with regulating gates, capable of holding up the comparatively clear winter waters for use during summer time. Examination of the Aswân site shows that the river is bordered by hills, rising considerably above the maximum flood level, while the intervening space is occupied by various islands and rocky islets dividing the river into a number of channels. Formerly, the Nile rushed down the rapids known as the First Cataract, but this natural feature has been abolished by the completion of the Aswân dam. The original designs presented by the Director-General represented a succession of independent dams following the course indicated in Fig. 20. Engineers are by no means unanimous as to the advantages of curved dams, and it may be said that there are few examples where the principle of the arch has been relied upon for saving width of masonry. The most noteworthy of such is the Bear Valley dam, in California, and in this the stress per square foot is so great that collapse of the entire structure would certainly follow fracture at any point. Another question upon which authorities differ is the effect of temperatures, some contending that the resulting stresses are more severely felt in a curved than in a straight dam, while others take the opposite view. We need not enter upon a discussion of these technicalities, but in justice to the Director-General it should be said that the original designs were believed to follow the line of

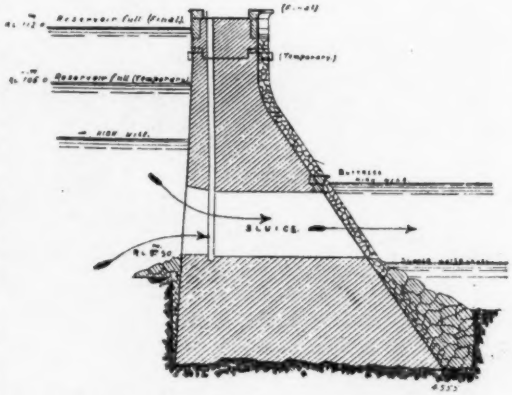


FIG. 21.—CROSS-SECTION OF ASWÂN DAM WHERE PIERCED FOR SLUICES, SHOWING TEMPORARY AND FINAL RESERVOIR LEVELS.

soundest rock at the Aswân Cataract—a matter of vital importance. Sir William Garstin, who had succeeded to the position of Under-Secretary of State for Public Works, gave his opinion in favour of the Aswân site, but decided to refer the whole matter to an International Commission consisting of Sir Benjamin Baker, Signor Giacomo Torricelli, and M. Auguste Boulé. When the International Commission met, the site and the type of dam proposed were approved, but it was thought that a single dam across the Cataract would be better than a series of detached dams. Although the original profile was sufficient to ensure stability and to keep all stresses within perfectly safe limits, the Commissioners, and especially Signor Torricelli, thought it well to insist upon still more stringent conditions of theoretical pressure and stability. Another question discussed related to the Temple of Isis on Philæ Island. The height of the dam recommended in 1894 was to have been such as to hold water up to R. L. 115 (*i.e.* 115 metres above sea level), and the capacity of the reservoir would have been about 2,400 million tons of water. This meant submersion of Philæ for a certain period every year, and the remedy suggested by the designer was to remove the Temple to Bigeh Island, at a cost of £250,000, this proposal being approved by the Under-Secretary of State. The International Commission were by no means agreed upon the best policy to pursue. M. Boulé refused to countenance any interference with the Temple; Signor Torricelli expressed the opinion that he had been called in to decide engineering rather than archæological problems; and Sir Benjamin Baker, while fully recognising

FIG. 22.—GENERAL VIEW OF ASWÂN DAM: DOWNSTREAM SIDE.

the fact that temples were of less value to Egypt than water, proposed to raise the Temple of Isis so that it should always be above the highest level of the proposed reservoir. The result was, that a majority of the Commission reported in favour of a dam to hold up water practically to the height intended by the Director-General. M. Boulé, however, presented an independent Report expressing the opinions that the selection of Aswân as the only possible site arose from the choice of a wrong type of dam, and that the masonry dam approved by his colleagues would be of inadequate strength. His scheme was to divide the fall into stages, and to construct a series of "movable" dams. For the purpose of demonstrating the applicability of his idea to high dams, M. Boulé worked out an example of such a dam, 92 ft. high, suitable for the Kalabsheh site, and to hold up 3,600 million tons of water. In this scheme the fall was divided into four equal stages, the lowest weir being in two panels, and the others in four, six, and eight panels respectively. Fifty sluice channels were proposed per weir, each 16·4 ft. wide between the piers, closed by 200 shutters ranging in height from 23 ft. to 92 ft., all these shutters having to be raised and lowered for regulating the reservoir. M. Boulé believed that a movable weir of the kind could be built for half the cost of the masonry dam proposed for Aswân, but needless to say, the flimsy type of construction he advocated was not very seriously considered. The project was practically demolished by the criticism of Sir Benjamin Baker, who pointed out that a few Dervishes with a Nile-boat loaded with gunpowder might very easily blow

FIG. 22 (CONTINUED).—GENERAL VIEW OF ASWÂN DAM: DOWNSTREAM SIDE.

up M. Boulé's 92 ft. high shutters, when the rush of the water impounded would sweep away the whole affair, carrying ruin and desolation to the country below. On the question of expense, it was pointed out that the Nile barrage, built by French engineers, had cost quite as much as the estimated price of the dams proposed by M. Boulé, although it only held up 12 ft. instead of 92 ft. of water.

The net upshot of the deliberations of the International Commission was, the recommendation that a straight-line dam should be constructed to hold up water to R. L. 114 across the head of the Aswân Cataract. Accordingly the Director-General received instructions to prepare another set of designs, following the line A. M. in Fig. 20. These designs were duly prepared and presented in 1895, together with a final Report. As the Caisse de la Dette, the International Committee controlling the surplus funds at the disposal of the Egyptian Government, refused to permit Egypt to spend money on these admittedly beneficent works, the whole scheme was again shelved. Even when financial difficulties had been overcome, a further complication arose owing to the agitation of antiquarians and others on the question of the Philæ Temple; and finally, a revised project was prepared for a dam to hold up water to R. L. 106, thereby reducing the estimated capacity to nearly 1,000 million tons. Fortunately the conditions as to stability insisted upon by Signor Torricelli, and agreed to by Sir Benjamin Baker, were so ample that it was possible for the dam to be re-designed on such lines that, although only required to hold up about 1,000 million tons, it would be capable of holding up double that weight, after the addition of a few feet of masonry. The cross-section given in Fig. 21, shows the dam as it will be when finally completed, and indicates the height to which it has now been built.

The Director-General of Reservoirs preferred the original alignment, which in his opinion followed the line of soundest rock at the cataract, but the International Commission insisted upon the desirability of a straight-line, and the Under-Secretary accepted their decision. Hence it became necessary for Mr. Willcocks to choose the best straight-line of rock that he could find at the site selected. Having done this, he prepared the designs which have since been realised, and retired from the Egyptian service in the year 1897. The late Mr. W. J. Wilson was then appointed Director-General of Reservoirs, and in the year following the works were commenced under his supervision, with the co-operation of Sir Benjamin Baker, who had been appointed consulting engineer to the Egyptian Government after the International Commission had concluded their labours.

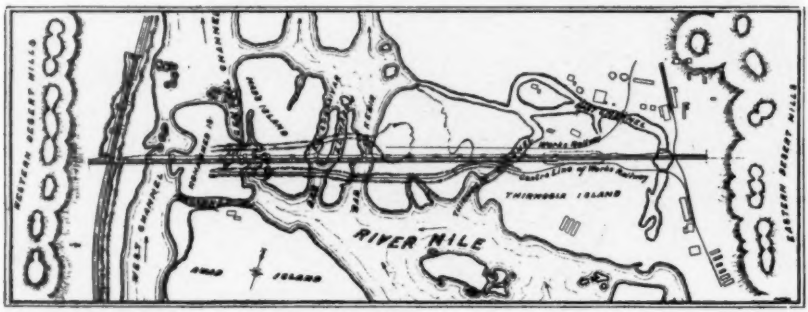


FIG. 23.—GENERAL PLAN OF ASWÂN DAM.

Various conflicting statements have

been made as to the nature of the contract relating to the construction of the Nile Reservoir Works, and as to the amount to be paid to the contractors. The estimated cost has been stated to be as little as £1,750,000, and as much as £5,000,000, while sundry intermediate amounts have been mentioned. We therefore think it well to quote the following particulars from the Report made by the Under-Secretary of State for the year 1901 :—

"On the 21st February, 1898, a contract was signed by His Excellency Hussein Fakhry Pasha, Minister of Public Works, and Messrs. John Aird & Co., by which the latter undertook to construct the Aswân dam, and Asyût Barrage, and all connected works for the sum of £2,000,000, payment being made by sixty half-yearly instalments of £78,613, commencing on the 1st July, 1903, the date fixed for the completion of the works.

"As the works have progressed more rapidly than was originally anticipated owing to the very low levels in the river, the monthly certificates have been met by payments partly in 'Mandats' and partly in cash, advanced by the Finance Ministry. Moreover, during the progress of the works large excesses have occurred in the excavation of the foundations, owing to the bad rock met with, which has necessitated similar excesses in the masonry; these excesses, together with auxiliary works, will probably cause a final expenditure on all the works of £3,340,000, the excess of £1,340,000 being paid in cash advanced by the Finance Department, and refunded by the Caisse de la Dette in two equal yearly payments of £670,000.

"The contractors are paid each month the amount of the Engineer's certificate either in cash or its equivalent; moreover, monthly advances have been made on plant, materials, and preliminary works, which are now being rapidly recovered as permanent work is being completed."

FIG. 24.—ASWÂN DAM: SHOWING ENTRANCE TO UPPER LOCK IN NAVIGATION CHANNEL.

From the first paragraph of the foregoing statement, it would appear that the original terms contemplated a system of deferred payment spread over a period of thirty years, the cost being thereby increased from £2,000,000 to £4,716,780. It seems, however that arrangements were subsequently made for the payment of cash, so that the total, including unforeseen expenditure, was not expected to exceed the sum of £3,340,000.

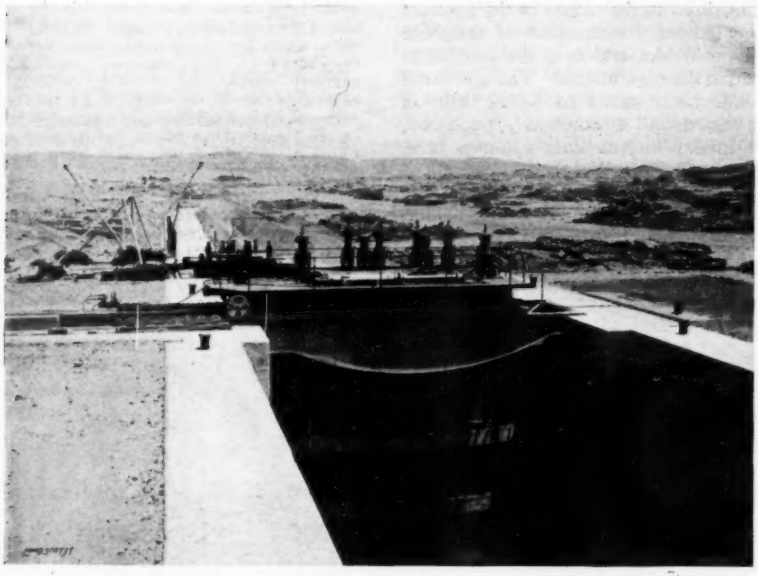


FIG. 25.—ASWÂN DAM: SHOWING INTERMEDIATE LOCK GATE.

The total payments made up to the end of the year 1901, were as follows:—

	£
Aswân Dam...	2,021,691
Asyût Barrage and Lock ...	883,946
Subsidiary Works	12,876
Total	£2,918,513

As the quantity of work remaining to be executed in 1902 was comparatively small, it becomes evident that the last estimate of expenditure affords a reasonable criterion of the total cost of the works.

As already stated, and indicated in Fig. 19, the object of the Aswân dam is to establish a reservoir controlling the whole water supply of Egypt during the summer months. The dam is of the insubmergible type, provided with a sufficient number of sluices to permit the whole Nile flood to pass without appreciable loss of velocity and without deposition of silt. The mean maximum flood of the Nile is 2,200,000 gallons per second, discharging at a velocity of 16·4 ft. per second; but in a year of very high flood the discharge may rise to over 3,000,000 gallons per second. About the end of November, when the water has become comparatively clear, the filling of the reservoir will be commenced by gradually closing the sluices, the maximum level being attained during January or February. Surplus water will then be allowed to pass into the river below by slightly opening some of the sluices. During the month of May, the normal discharge of the river will be augmented by the release of impounded water, as shown in Fig. 22, and the reservoir will be empty in the middle of July at the beginning of the annual flood. The mean summer discharge of the Nile is 90,000 gallons per second, the minimum discharge being about 44,000 gallons per second. The actual capacity of the reservoir is now estimated at 1,050 million tons, which it is believed will always assure a summer supply of water fully equal to the mean discharge of the river.

The Aswân dam is 2,187 yards in

length, extending in a straight line across the valley, as indicated in Fig. 23. Its width at top is 23·6 ft., and at its deepest part 82 ft., the maximum height being 131 ft. The interior masonry is granite rubble in 4 to 1 cement mortar, the exterior casing being large squared rock-faced granite in 2 to 1 cement mortar. The dam is pierced by one hundred and forty lower sluices, 23 ft. high by 6·5 ft. wide, and by forty upper sluices, 11·5 ft. high by 6·5 ft. wide. These sluices are fixed at different levels, so as to allow the discharge of water conformably with variations of level in the reservoir; the highest having a head of 19·6 ft. over the sill, and the lowest a head of 60·6 ft. The sluices are separated by piers 16·4 ft. wide, and are arranged in groups of ten, each group forming a bay. Between the bays are abutment piers 32·8 ft. wide, and at such parts the section of the dam is increased by 3·28 ft. of additional masonry. All the sluices, with the exception of thirty in the lower range, are lined with heavy granite ashlar. The thirty sluices in question are lined with cast iron, this form of construction being thought necessary for the purpose of saving time, owing to the comparatively short season available for building. Regulation of the sluices is effected by means of steel gates, fifty-six in the lower tier being of the ordinary kind, while the remainder, and all those in the upper tier, are of the well-known Stoney type, working on free rollers suspended in frames. A hand-winch is fixed over each sluice for regulation of the gates. On the western flank of the dam a navigation channel has been made, 2,185 yards long, with a bed width of 16·4 yards, the intake is well away from the draw of water on the up-stream side, and sufficiently removed from the wash on the down-stream side. There is a ladder of four locks, and the alignment of the dam traverses the navigation channel just upstream of the first lock, as may be seen generally by reference to Fig. 23, and in detail by examination of Fig. 26. The total fall of 68·8 ft. is divided into three drops of 19·68 ft., and one of 9·84 ft.

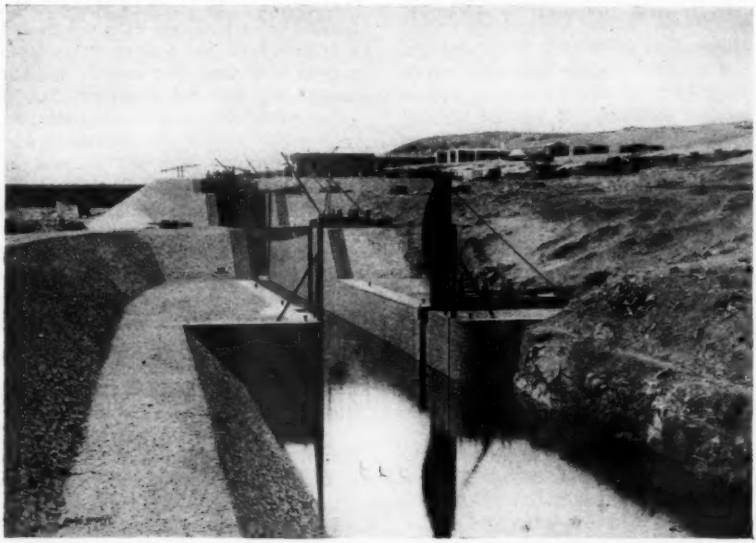


FIG. 26.—ASWÂN DAM: SHOWING THE LADDER OF FOUR LOCKS, WITH DAM IN THE BACKGROUND.

Each lock is 230 ft. long by 32 ft. wide. The lock gates were designed by the late Mr. F. D. M. Stoney, the inventor of the Stoney gates, and have been built and erected under the direction of Mr. Wilfred Stokes, M.Inst.C.E., Engineer to Messrs. Ransomes & Rapier, who were sub-contractors to Messrs. John Aird & Co. for the whole of the ironwork. There are two lock gates 59 ft. high, and the approximate heights of the remaining three are 46 ft., 36 ft., and 26 ft., respectively. The great height of the upper lock gates was necessitated by the fact that navigation must be provided for when the reservoir is full. Fig. 24 is a view of the entrance to the first lock, and it may be remarked that each of the upper gates is strong enough to hold up the water of the reservoir, assuming all the other gates to be destroyed. Each gate consists of a single leaf, rolling back into a recess in the side of the lock wall, and perpendicular to the direction of the lock, as shown in Fig. 25. A lift bridge is hinged to, and forms the continuation of a fixed bridge over the recess, these bridges carrying a line of rails on which the gate-carriage runs supported by numerous rollers. When the lock is open, the lift bridge stands in a vertical position, and the gate is suspended within the recess, as may be gathered from Fig. 26, which is a view showing the range of locks from the lower end. To close a lock, the lift bridge is lowered, the carriage carrying the suspended gate is rolled across the opening, and the gate then bears against steel quoins at the sides and a steel sill at the bottom. These operations are performed by hydraulic power generated by a small turbine fixed in the dam. Part of the machinery may be seen in Fig. 25. The locks are filled and emptied through valve openings in the gates, the headstocks of the valves being shown in the same illustration. So far as navigation is concerned, a great benefit has followed the completion of the dam, for whereas river traffic was formerly only possible during certain months, it can now be conducted without interruption throughout the year.

These are the salient features of the great dam which was finally dedicated to the public service in December last, and in the concluding article we propose to give some brief account of the labours involved in its construction.

(To be continued.)

Byker Bridge (Widening), Newcastle-on-Tyne.

Byker Bridge spans the Ouseburn Valley and connects the outlying districts of Heaton and Byker with the East end of the city. The bridge was originally built entirely of brick and is 1,280 ft. long, consisting of 14 arches of 66 ft. span, and eight arches of 30 ft. span, and was built and owned by a private company about the year 1879.

A few years ago the bridge became the property of the Corporation, who immediately made it free, toll having previously been charged. As will be seen from the illustrations the bridge was 30 ft. 6 ins. wide, with a 7-ft. footpath at one side and a single line for trams on the other. The traffic over the bridge has increased considerably during the last few years.

The Corporation therefore decided to have the bridge widened by the addition of a 10-ft. footpath on each side, making the total width 52 ft. 6 ins., and to have a double line of tram rails, provision having to be made for the water and gas mains, etc., together with the electric cables under the new footpaths.

The whole of the work was entrusted to the Tees Side Bridge and Engineering Works, Ltd., Middlesbrough, whose design was accepted.

One of the most important conditions of the contract was that whilst the foot traffic must be kept open during the whole time of the continuance of the operations and the vehicular traffic be stopped only when absolutely necessary, the work was so arranged that practically both foot and vehicular traffic were not interfered with during the progress of the work.

On reference to the illustrations it will be seen the widening was accomplished in the following manner :—

The brick parapet was taken down on the north side, and the new footpath and half the roadway completed before disturbing the other.

Steel cantilever girders, riveted up in one piece 52 ft. 6 ins. long by 2 ft. 6 ins. deep, are used to support the ends of the longitudinal girders : these girders were inserted through the jack arches immediately over each main pier, the spandril walls having previously been broken through and granite padstones set to the required level, most of the load being carried directly down the piers to the foundations. It will be observed that by this method the load is in a great measure transferred from the crown of the piers, which is a most important item in the design.

After the steelwork was in position and set, the ends of these girders were bricked in and made good.

Expansion is provided for at the ends of each longitudinal girder, *i.e.* every 66 ft.

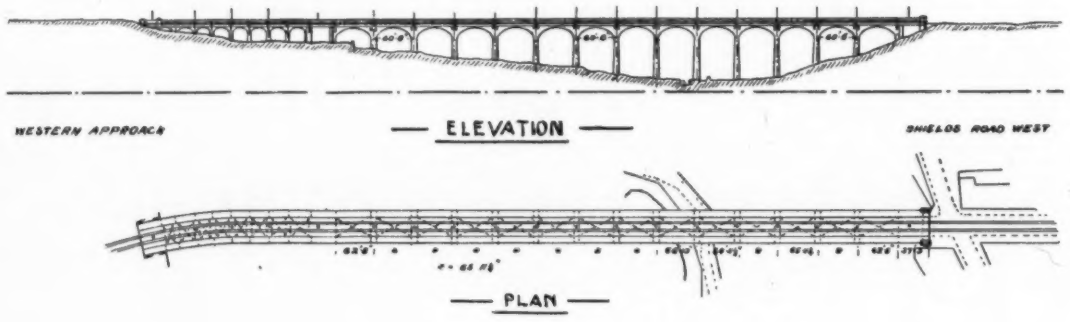
At the smaller arches steel cantilever brackets 10 ft. wide by 12 ft. deep are used to carry the side girders. These brackets rest on granite corbels let into the piers and set to suit the gradient. Care was taken in the design of these brackets that most of the weight was transmitted to the face of the solid brickwork, to relieve the corbels as much as possible.

Each pair of brackets is held in position by steel tie-rods stretching across the bridge under the roadway.

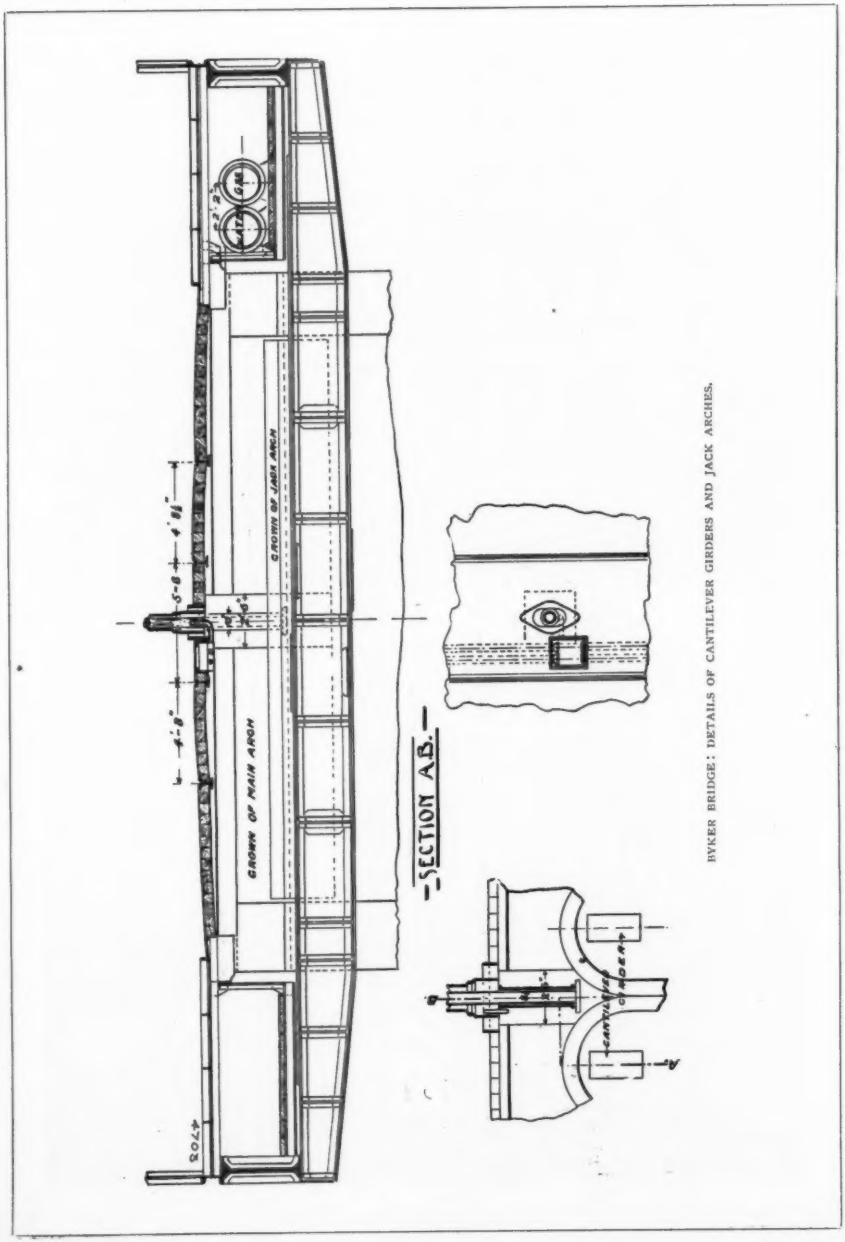
Main girders are 3 ft. 9 ins. deep and generally 66 ft. long, the ends being carried on cantilever girders or brackets, and are calculated to sustain a live load of 1 cwt. per square foot, in addition, of course, to the dead load.

The parapets are 4 ft. high, of the lattice type, with a moulded teak handrail secured to the flange at the top of the parapets by coach screws.

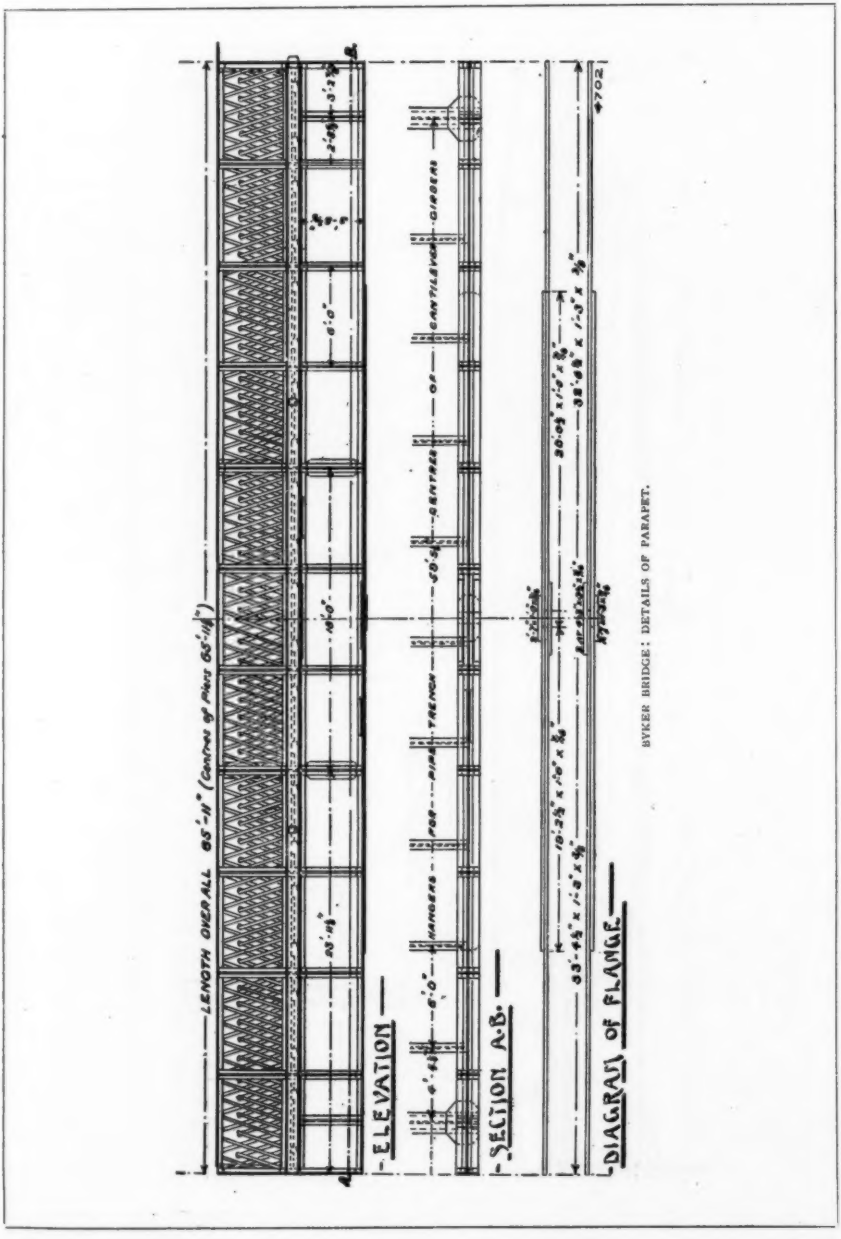
The footpaths are laid with ferro-concrete flags 3 ins. thick, bedded on steel **T**'s placed longitudinally with the bridge and supported on steel cross-bearers of



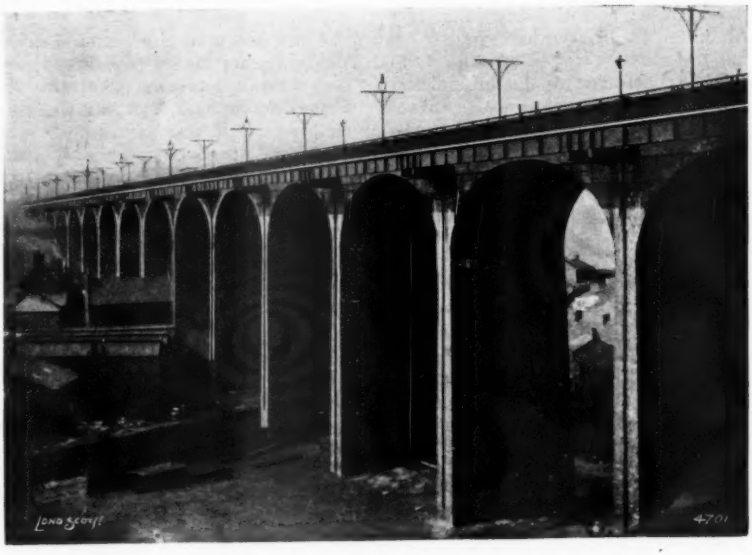
BYKER BRIDGE: ELEVATION, PLAN, AND CROSS-SECTIONS OF CANTILEVER GIRDERS, AND BRACKETS.



BYKER BRIDGE: DETAILS OF CANTILEVER GIRDERS AND JACK ARCHES.



BYKER BRIDGE: DETAILS OF PARAPET.



VIEWS OF THE BYKER BRIDGE.

channel section, placed 3 ft. apart. These channels are bolted to the top flange of the main girders, and the ends that rest on the bridge are bricked in.

Pipe trenches are provided under the footpath on each side of the bridge, and are laid with 3-in. creosoted deals. Manholes are placed at convenient distances for easy access to the trenches.

The paving, curbing, flagging, and tram rails as they existed before the widening were taken up, and all ballast removed down to the ½-in. asphalte course, and the new roadway was then paved with 4¾-in. Jarrah wood on concrete, and finished to new level, *i.e.* 6 ins. lower than the old level. A substantial cast-iron gutter was laid on each side for the full length of the bridge, with gullies at suitable distances connected to 6-in. by 4-in. cast-iron fall pipes fixed to the outside of the main piers.

The effect of the widening will be better appreciated from the following statement, viz :—

The amount of the material added to the bridge for the purpose of widening per bay of 66 ft., including steelwork, timber, ferro-concrete flags, gas and water mains, etc., is 76 tons, and the amount removed in stone string-course, brick parapets, coping, and the reduction in level of the roadway is 135 tons; therefore the dead load on each pier is reduced to the extent of 59 tons, and although 20 ft. is added to the width, the weight on the foundations remains about the same. Work was commenced on the north side in the latter part of April 1901, and half of the roadway was paved, footpath completed, and one line of trams opened in the following March; the second line in June; and the whole bridge was completed in August, 1902.

The Paris Metropolitan Railway.

By JACQUES BOYER.

(Continued from page 220.)

❀ ❀ ❀

Rolling Stock of Paris Metropolitan Railway.

The rolling stock of this railway comprises—

1. Two types of trailer carriages, and
2. Two types of motor carriages, with one and two drivers' or wattmen's "cabs" respectively.

The trailer carriages (shown in Fig. 11 coupled to a motor carriage) consist of a body 8·70 metres long, 2·40 metres wide, and 2·30 metres high, containing 10 transverse rows of seats arranged back to back in pairs, and divided by a longitudinal corridor 85 centimetres wide (Fig. 24), there being ten single seats on one side and ten double seats on the other side of the corridor; or, in all, accommodation for thirty seated passengers, while there is standing room for about twenty persons besides. As a matter of fact, at the busiest hours of the day, from fifty to sixty passengers are allowed to travel in each carriage.

In the first-class carriages the seats and backs are upholstered and covered with reddish-brown leather, while in the second-class carriages they are varnished wood-latticed or "garden" seats, as shown in Fig. 24. On each side of the carriage there are two sliding doors, one for the passengers coming in and the other for passengers leaving. From the main conductor sufficient current is derived for the illumination of the interior of each compartment by means of six incandescent lamps placed along the axial line of the ceiling, while four additional lamps (lanterns) are arranged in the corners.

The motor carriages (Figs. 25 and 26) are all second-class carriages, and differ from those mentioned above merely in the addition to their ends of special compartments or "cabs" for the driver (who is shown at his post in Fig. 11). Within this "cab" are placed all the starting and controlling machinery, the cocks or valves for operating the pneumatic brakes and the sand-box. The main switch is fixed at the left-hand side of the cab, and below it is the air compressor.

The first type of motor-carriage is provided with a driver's cab at one end, and the second type has a cab at each end. This arrangement offers a great advantage, because, at the termini, the trains, after having passed around the loop, are immediately in position for travelling in the opposite direction. Current is obtained from the conductor-rail through the medium of a friction-block loosely suspended below the oil-boxes. An insulated cable, leading from this block or "shoe," conducts the current to the two Westinghouse electric motors used in propelling the vehicle. Each of these motors possesses a power of 100 h.p. and a speed of 400 revolutions per minute. In addition to the compressed-air brake each car is fitted with a hand-operated brake, while in an emergency the motors themselves may be used as brakes by simply reversing the motion.

There is reason for believing that emergencies will rarely, if ever, arise, seeing that Hall's "block-system"—which has been adopted for the Paris Metropolitan Railway—may be said to have attained perfection in this class of apparatus. The safety device on this system, the operation of which is entirely automatic, obviates the necessity of employing special line-blockers and protects each train in the rear by means of two signals. It is the train itself that blocks the line immediately behind it, and re-opens it for a certain distance behind by the action exercised by the tyre of one of the front wheels, while at the same time operating a signal which opens the line that had previously been blocked, and also the signal of the next

section which is to be blocked during the passage of the train.

Electric Power Station.

Until about the middle of 1901, pending the completion of the Bercy power-station of the Metropolitan Railway Company, now erected between the Quai de la Rapée and the Rue de Bercy, the electric energy necessary for working the line had been supplied by the Compagnie Parisienne de l'Air comprimé, the Compagnie du Triphasé, of Asnières, and from the

FIG. 24.—INTERIOR VIEW OF A SECOND-CLASSS CARRIAGE.

station of the Compagnie Générale de Traction. Now, however, all the current is furnished by, and distributed from, the company's own power-station, and the two sub-stations of Étoile and Champs-Élysées.

The Metropolitan Railway power station, (Fig. 28), whereof the whole installation was completed by the great Creusot firm of of Schneider & Co., consists of a range of buildings facing the Quai de la Rapée, the boiler and machine sheds being at the rear. The boilers (Fig. 27), now numbering thirty, are arranged in five sets or groups, and are of the semi-tubular type, with two plain water-cylinders connected by three water-tubes to the main portion, which is fitted with fire-tubes. The total heating surface is 244 square metres. Steam is supplied at a pressure of 10 kilogrammes per square centimetre. The system of feed-pipes and the steam-collecting main are arranged in loops, and in order to circumscribe the effects of any damage that might occur in any part of the system, stop-valves are placed at intervals along the pipes. The ash-boxes open into a gallery extending along the boiler-house and terminating at a hoist. Coal is supplied by barges brought up to the landing-place facing the works, where an electric crane raises it to a hopper, which continuously discharges its contents into a system of conveyors and elevators, by means of which the coal is delivered

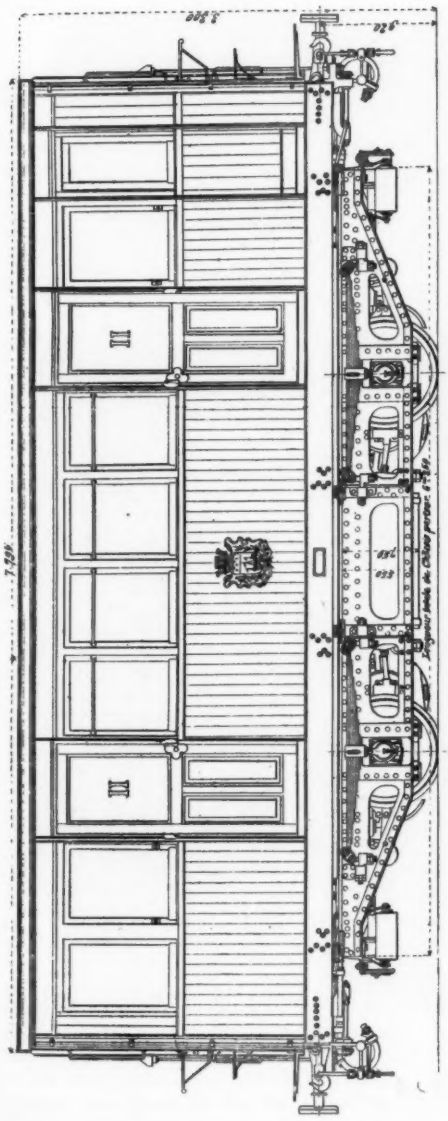


FIG. 25.—AUTOMOTOR CARRIAGE WITH TWO ENGINEERS' CABINS.

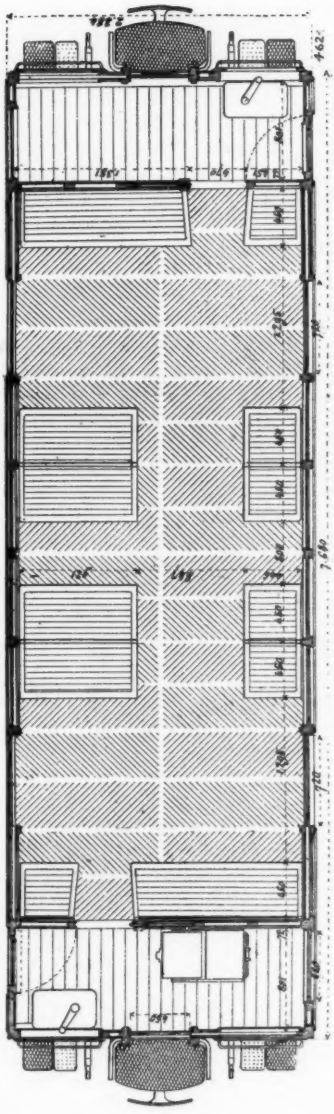


FIG. 26.—SECTIONAL VIEW OF THE SAME CARRIAGE.

to the coal-bunkers after having been weighed by automatic weighing machinery. The complete apparatus is timed to transport and deliver 62 tons per hour, and requires 20 h.p. for its operation.

The four steam engines (Fig 28) are of

the vertical compound condensing type, running at 60 revolutions per minute, and capable of developing 2,600 h.p. each. The fly-wheel and dynamo of each are mounted between the cylinders, and each complete engine rests upon a solid foundation 11 metres long, 10·50 metres wide and 12 metres deep, the fly-wheel alone weighing 63,000 kilogrammes, while the weight of the driving-shaft, together with its cranks, is 20,000 kilogrammes. Each engine is fitted with two governors, one of which controls the valve-gear, while the other acts through the medium of auxiliary engines for the purpose of checking any tendency to racing, in which case the checking action is exercised upon a valve arranged at the steam inlet. The rate of speed is regulated at will by means of the first-mentioned governor.

One of these engines drives a 1,500-kilowatt direct-current dynamo, generating current at 600 volts; and the three remaining steam-engines are directly coupled to 1,500-kilowatt triphase alternators, supplying current at 5,000 volts with a frequency of 25 periods per second.

There are, further, at the Bercy power station, two classes of continuous-current transformers: those of one kind, of 65 kilowatt power, reduce the difference of potential from 600 to 130 volts and serve for exciting (Fig. 29), while the others, of 200 kilowatt power, serve as boosters (Fig. 30). They convert 600-volt current into current whereof the voltage is variable automatically, availing themselves of the assistance of batteries of accumulators in charging and discharging, with the object of ensuring constancy of the voltage as far as practicable. The machine-room also contains transformers and rotary converters, permitting the triphase-current alternators to be utilised at the power-station direct by first reducing the tension from 5,000 to 430 volts, and then transforming the triphase current into 600-volt continuous current.

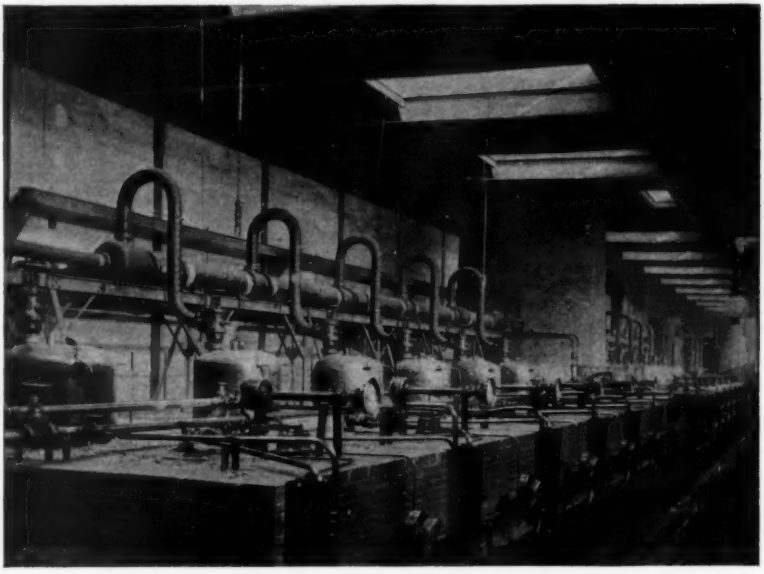


FIG. 27.—BOILER ROOM AT THE GENERATING STATION.

FIG. 28.—MACHINE ROOM AT THE GENERATING STATION.

One noteworthy fact in connection with the general system of distribution is that the Étoile sub-station, situated about 12 metres below the roadway, supplies energy to the western portion of the Metropolitan line, which is not supplied direct from the main power station. Cables laid along the railway line serve to conduct 5,000-volt current from the generating station and to distribute it to the motors of the carriages, after it has been transformed into 600-volt continuous

current. This sub-station also contains a battery of "Tudor" accumulators working at 1,800 ampères per hour, and acting as a voltage-regulator. The Champs-Élysées temporary sub-station comprises two 750-kilowatt converters, which receive through "parallel" connection 5,000-volt triphase current, and then transform it into continuous current, to be sent in due course through the conducting rails of the line.

I may here mention that works for the enlargement of the Metropolitan Railway power station are now in progress, so that by the beginning of 1904 the equipment will include eight sets of 1,500-kilowatt generators, which will no doubt be necessary by reason of the increased development which the Paris Metropolitan Railway system will have reached by that time.

Remarks concerning the Working of the Paris Metropolitan.

I may conclude this notice by stating a few general facts concerning the practical working of the railway.

Owing to the arrangements which have been made, the trains on line A travel at a "commercial" speed of 21 kilometres (about 15 miles) per hour, and the whole journey from Vincennes to the Port Maillot, is completed in 30 minutes. In order to enable this result to be attained, notwithstanding the small distances at which the stations are placed from each other, special efforts have been made to reduce the total duration of the stoppages to 30 secs., including use of brake, stoppage proper, and re-starting The trains succeed each other at three-minute intervals, running from 5.30 a.m., until 8 p.m.; while between 8 p.m. and 1 a.m., trains are run at six-minute intervals.

In the Étoile and Port Dauphine, and the Trocadero sections, and also over part of line B (Étoile and to Rue de Bagnolet station) now in use, trains are run only at six-minute intervals.

This mode of transport has met with great favour with the Parisian public, as statistics have shown. Thus, for 1901, the traffic was 4,800,000 passengers per kilometre and per annum. During the first seven months of 1902, the Metropolitan line was patronised by an even larger section of the public, since 33,611,630 passengers were recorded for that period, while the total receipts for those seven months amounted to frs. 5,816,860.

In only one respect may fault be found with the engineers, and that is in the ventilation of the tunnel, which at present appears inadequate. In fact, the passages leading to the platforms at the stations and the motion of the trains are now alone relied upon for ventilation. Nor is this drawback by any means minimised by the presence of the creosote-impregnated

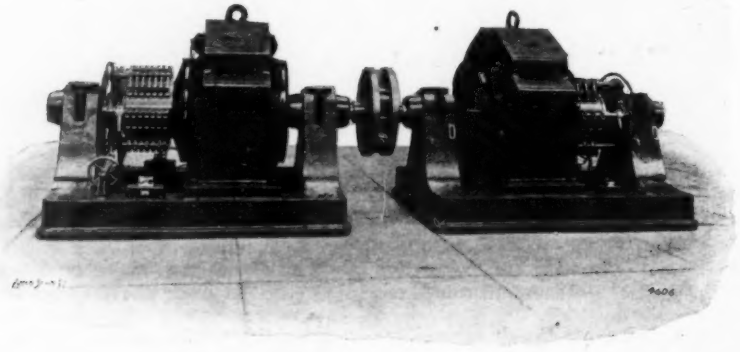


FIG. 23.—EXCITER SET.

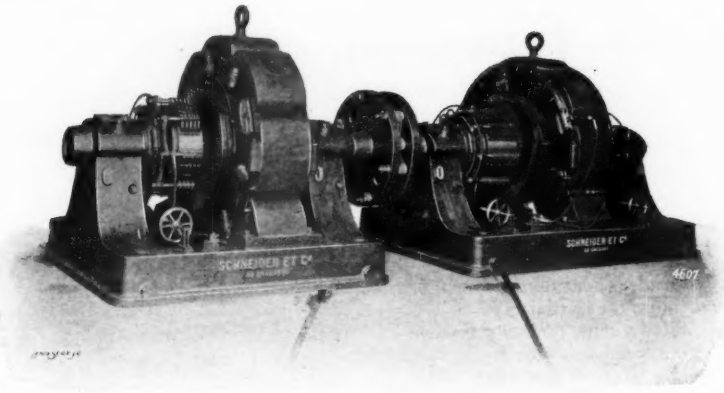


FIG. 30.—BOOSTER SET AT THE GENERATING STATION.

sleepers, which give off an odour that is neither pleasant nor healthy to inhale. But the light-hearted Parisians cheerfully put up with slight inconveniences of this kind, while the company (be it said to their credit) are now making an honest effort to improve the existing atmospheric conditions. Granting, therefore, that Paris was the last of the great capitals of the world to possess a Metropolitan Railway of its own, there can be no doubt, in view of the brilliant start it has now made, but that before very long it will be endowed with the one of all existing urban or suburban railway systems which is worked and managed in the most intelligent manner, and which beats all its rivals in regard to speed.

Laundry Engineering.

By F. J. ROWAN, A.M.Inst.C.E.

(Continued from page 37.)

Of what may be termed accessory apparatus which is necessary in the engineering of laundries, the variety is considerable. Amongst the most important articles of that class are undoubtedly fans, not only because of their use in connection with drying closets, but also because of the vital necessity for thorough ventilation in all properly arranged laundries. No doubt a certain movement of air may be obtained by means of what is termed "natural draught," but both economy and efficiency are in favour of mechanically produced currents, even were there not considerable volumes of water-vapour present to complicate the process, as there are in all laundries. On the question whether the fans should be used for exhausting or for a blowing action there are of course different opinions, but probably the best results are obtained by using the exhausting action for ventilating and the blowing or pressure action for drying operations.

It would obviously be impossible to attempt a description of the numerous designs of fans which are in use, or even to describe the more important ones in this series of short articles. Perhaps the best known designs are the "Sun," the "Sirocco," the Blackman and the Sturtevant fans, and of these we illustrate the first two.

Fig. 1 shows the fan made by the Sun Fan Co. of Bradford for a belt drive and Fig. 2 shows their "double-effect" fan, also belt driven, the latter being especially suitable where reversals of the currents may be wanted and for an increased pressure of blast. These fans are also

FIG. 1.—BELT-DRIVEN FANS, FOR VENTILATING DRYING, AND COOLING PURPOSES.

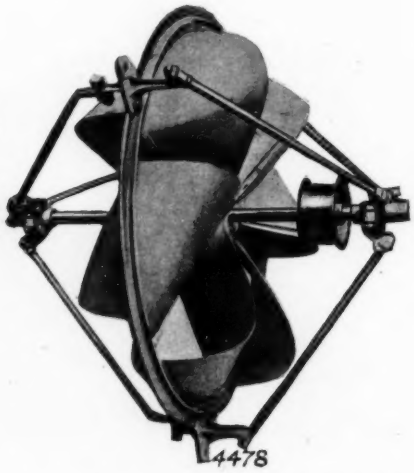


FIG. 2.—DOUBLE EFFECT FANS, WHICH ARE ALSO REVERSIBLE. ESPECIALLY EFFICIENT FOR HIGH PRESSURES.

FIG. 3.—DAVIDSON'S "SIROCCO" FAN.

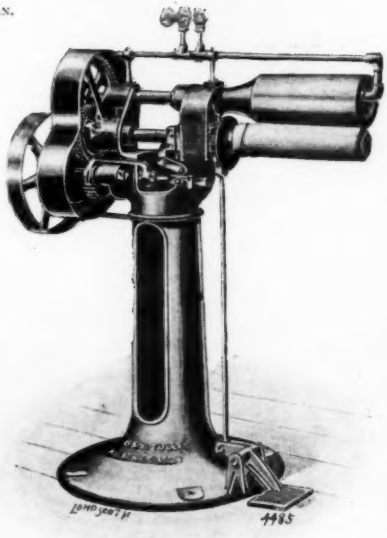


FIG. 4.—MESSRS. D. AND J. TULLIS' IRONER.

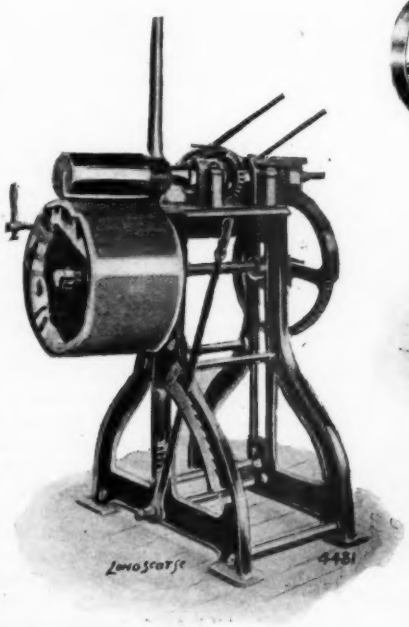


FIG. 5.—THE CHERRY TREE CO.'S IRONER.

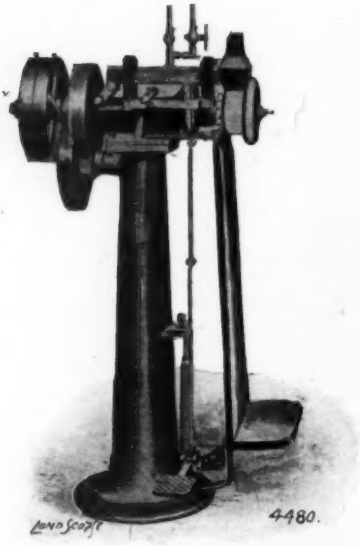


FIG. 6.—NECK-BAND IRONER.

FIG. 7.—BRADFORD'S "TYLER" POLISHER.

arranged for direct electric driving and apparently give high efficiency. The "Sirocco" fan of Messrs. Davidson & Co. (Fig. 3) has also an excellent record.

Connected with fans are the various appliances for producing the supply of hot air required for drying. Various kinds of stoves are employed, but the most general arrangement is a coil of pipes in which steam is used, and where a supply of exhaust steam from engines is available that offers the most economical method of obtaining the requisite amount of heated air. Some of the laundry buildings also require to be kept at a warm temperature, and this is most conveniently managed by means of hot air, the appliances just mentioned being employed for this purpose.

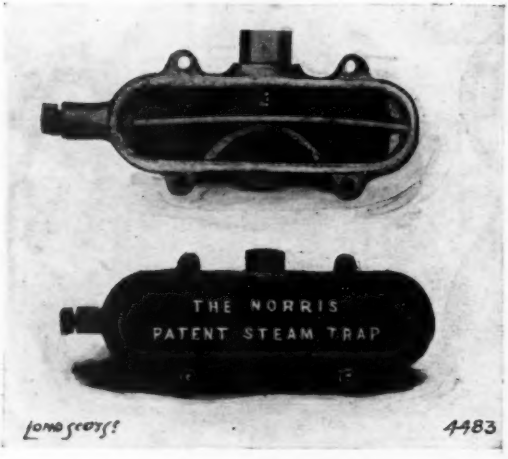


FIG. 9.—THE "NORRIS" STEAM TRAP.

The fact that a good deal of hot water is required outside of that which is used in the washing machines, and that steam is used for heating in these latter, as well as in ironing and other machines, indicates the necessity for the presence of a steam boiler in the equipment of a modern laundry. To some extent this weighs the

FIG. 8.—BRADFORD'S PATENT GOFFERING MACHINE.

balance in favour of a steam engine as the motor for driving machines, pumps, etc., but there may be circumstances, such as, for instance, a cheap supply of electric current and a high price for, or scarcity of, coal, which would render another system of driving desirable. Moreover the advantages of electric lighting may constitute an argument in favour of the electrical equipment of a laundry, although where a steam engine is used sufficient power may readily be provided to add a dynamo machine for the requisite current for lighting.

The atmosphere of steam laundries, unless with very perfect ventilation, is not eminently suitable for the installation of a separate electro motor to drive each machine; but of course that is not the only way in which the driving may be arranged, and it must be admitted that diminution in the extent of shafting and number of belts is advisable for several reasons.

Of the smaller class of machines the blouse or body-linen ironer by Messrs. D. & J. Tullis shown in Fig. 4 is a good specimen. The top roller is heated by a Bunsen gas flame, and a treadle lever permits of pressure being applied or the two rollers being separated. Fig. 5 by the

FIG. 11.—THE "NORRIS STEAM KETTLE."

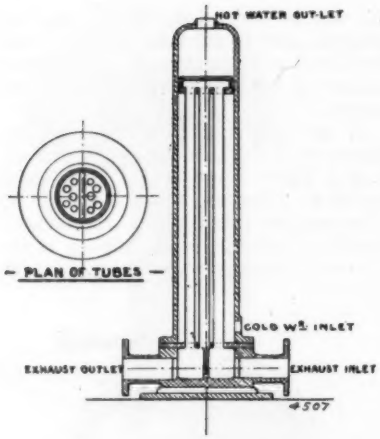


FIG. 10.—THE "NORRIS" FEED-WATER HEATER.

Cherry Tree Machine Co. has the peculiar feature of the large diameter lower or padded cylinder, and Fig. 6 by the same firm illustrates another variety in such machines and shows how the tendency is to specialization in the work for which machines are designed. This latter one is for ironing the neck-bands of shirts and other garments, on both sides, whilst Fig. 5 shows a machine for ironing collars, cuffs and shirt-fronts, in preference to the flat table machine. Fig. 7 shows a machine made by Messrs. T. Bradford & Co. for polishing the surface of starched articles; but there is little doubt that the high gloss often demanded is responsible for a good deal of the destruction or severe wear to which shirts, collars and similar articles are subject.

The hand system of ironing is not yet abolished, however much machinery has improved, and Messrs. Bradford have an arrangement for heating the irons internally by small blowpipe flames of gas. The electric current has also been tried for keeping the irons hot, but so far the gas and air arrangement is the more economical.

Before dismissing these accessory machines, reference must be made to a small class of machines, both hand and power driven, used for goffering or fluting (Fig. 8). They follow the lines of the body-linen ironers, and present no great divergence from that design.

Steam traps, steam kettles, feed-water heaters and numerous other fittings also form a necessary part of a laundry plant, and the following figures illustrate these appliances as made by Messrs. Norris & Son of Stalybridge and used in a large number of British laundries.

Fig. 9 shows the "Norris" steam trap, in which the bar *B* when exposed to steam temperature expands and closes the valve *C* in the inlet passage, whilst at the temperature of the water condensed from the steam it allows that valve to remain open.

Fig. 10 is the Norris feed-water heater which employs exhaust steam and has the additional advantage that the steam condensed in the operation can be collected and made use of.

The Norris steam kettle, Fig. 11, admits steam at *F*, through the vertical tubes *D* and top box *E* to escape at *G*, whilst the water enters cold at *H* and leaves boiling

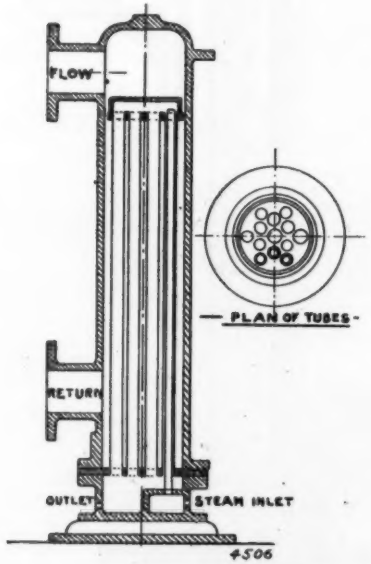


FIG. 12.—THE "NORRIS" CALORIFIER, FOR HEATING BUILDINGS BY HOT WATER.

at *J*. The novel feature of this kettle is the presence of a relief valve at *K* by means of which the expansion of the water, or any accumulation of steam escapes into the steam chamber *E* and prevents boiling back into the water main.

A "calorifier," or heater for water used to heat buildings by circulation through heater pipes, made by the same firm, which is shown at Fig. 12, is constructed on similar lines to the kettle, but has the hottest steam and water brought together at the top of the apparatus, and while the tubes are free to expand, the expansion of the casing is used to work a regulating or controlling steam valve according to the temperature. Of steam engines and boilers, pumps, injectors, hoists, clothes' wagons, barrows and vans, curtain frames and a host of other apparatus we cannot speak here. It will suffice to conclude these articles by reference to one important point which has already received a passing comment, and that is the introduction of safety appliances.

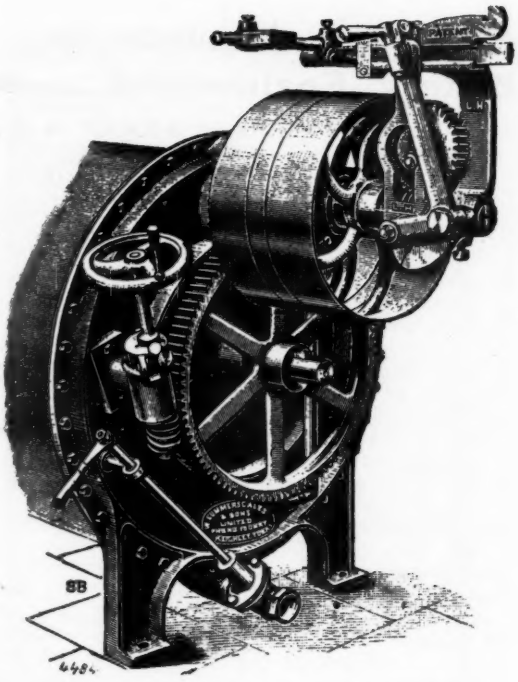


FIG. 13.—SUMMERSCALES' PATENT DRIVING AND LOCKING GEAR.

The washer of the Leicester Laundry Engineering Co., with its driving gear at the farther end of the machine from the operator, has been noticed in former articles. Of the same nature are Summerscales' rocking and hand turning gear, which is shown in Fig. 13, and Manlove, Alliott & Co.'s safety-feed bar arrangement for ironers, shown in Fig. 14. The former locks the belt guides when the machine is at rest, whilst the hand turning worm gear permits of movement to bring the door into position, and still further prevents movement when it is not desired. The latter appliance gives protection against the fingers or hand of the operator being drawn in with the cloth far enough to be crushed between the roller and the bed of the ironer.

The most skilful engineering always tends towards amelioration of the conditions of labour, even although the wear and tear of life are increased.

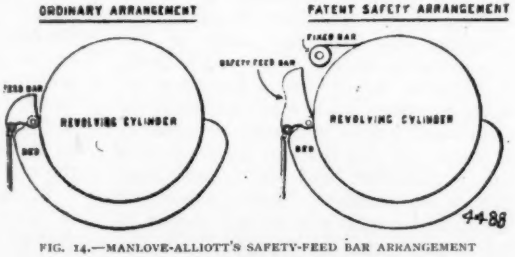


FIG. 14.—MANLOVE-ALLIOTT'S SAFETY-FEED BAR ARRANGEMENT FOR IRONERS.

A Recent Advance in Bakery Engineering.

By F. J. ROWAN, A.M.Inst.C.E.

IN these days of enlightened progress, improvements which are proposed in methods or apparatus of work must, if they are to be successful, secure either an economical or a hygienic gain. The former always commands attention in the industrial arts, and the latter as time goes on has its great importance more and more fully recognised. Where, however, both are found to be combined in the same improvement, there can be no question of its paramount value, and of the benefit which it can confer on every one. An advance of that nature has quite recently been made in the method of firing bakers' ovens by Messrs. W. F. Mason, Ltd., of Manchester, who are well known as pioneers of improvements in this branch of engineering.

The old methods of baking—mixing and kneading by hand, and baking in an oven heated by solid fuel (coke or coal), all the operations being carried out in the same room, which had to fulfil the functions of store, bakehouse, and stokehole all in one—such methods were extremely rude and undesirable, and yet they are still to be found in very small "bakeries," where sometimes the same hands which at one moment are mixing flour, eggs, butter, or other ingredients together, are the next moment shovelling fuel or removing ashes. Machinery for mixing and kneading has abolished some of the objectionable features of the old method, and now the new system of firing goes far towards perfecting the work of baking.

It is well known that firing by means of producer gas has been of great value in many industries, and every additional industry in which the heating operations are carried out by this method means so much more territory brought within the reach of col-saving appliances.

Statistics have shown that of the enormous quantity of solid fuel annually consumed in Great Britain, about 48 per cent. is used for industrial purposes in the production of power, some 30 per cent. for the production of heat in industrial operations, and about 22 per cent. for domestic uses. If we except the last for the moment, there is no good reason why the two former proportions should not be brought wholly within the range of the economies and advantages attaching to the use of gas. Even where much economy in weight or price of fuel is not possible, from the nature of the heating operations carried on, yet the prevention of smoke and the minimising of the formation of dust are important from a hygienic or sanitary point of view. In some industries, such as dyeing and cleaning or bleaching, the absence of dust is of far more importance than in others, but it would be difficult to find one industry to which cleanliness in the various operations is of such vital consequence as it is in that of baking.

To the ordinary baker the firing of an oven does not appeal as being anything beyond a part of his routine work, and he no doubt looks upon the presence of solid fuel in his oven or fireplace, with its attendant dust and ashes, as a necessary evil. What he really needs, however, is *the heat* obtained from the fuel, and if he can be shown how to obtain that without the presence of objectionable foreign matter in his bakehouse, a very good turn will have been done to him, and he may be trusted before long to submit gladly to the new *régime*.

In order to banish the idea that there is any mystery or uncertainty in the matter, it is only necessary for him to consider what takes place in ordinary

combustion, such as he can see proceeding in an open fire. He can notice in it the production of *flame* from the gases which are distilled off from coal by the action of heat, and which burn in contact with the air drawn towards the fire by the chimney draught, and he can also see the *glowing* coke or solid carbon being consumed away, burning in union with the air, but without flame. When the fire is deep and contains only glowing coke, a short flame of blue tint rises from its surface, and this is due to the fact that the carbonic acid gas, which is produced by the complete combustion of carbon in the lower layers of fuel, becomes reduced to carbonic oxide by contact with the hot carbon above in its passage through the fire. The flame shows the carbonic oxide burning again to carbonic acid when more air reaches it above the fuel. What escapes up the chimney in this case is a mixture of carbonic acid, steam and nitrogen, with the excess of air passing through or over the fire. When fresh coal is laid on a hot fire an immediate cooling may be noticed. The cold fuel absorbs heat—more or less according as it is wet or dry, but soon begins to give off streams

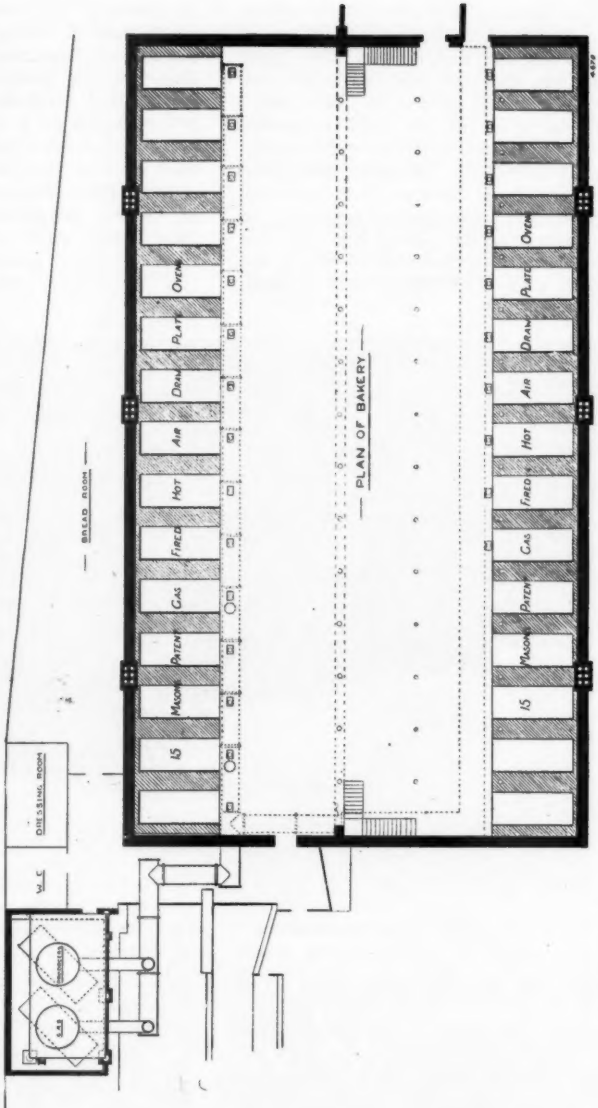


FIG. 1.—GENERAL ARRANGEMENT OF GAS-FIRED DRAW-PLATE OVENS AT MESSRS. JOHNSTON, MOONEY AND O'BRIEN'S BAKERY, DUBLIN.

of smoky gases of a black, grey, or yellow tint. As the heat increases tongues of flame shoot up, and soon all the gases rising from the coal take fire, and cover the upper surface of the fuel with flame. These gases are in this case completely burned to carbonic acid and water-vapour or steam as before. The gases first given off do not burn, because they have not acquired the temperature necessary to form flame, and the cooling action of the air which meets them above the fire causes them to alter their composition to make all the solid fuel into combustible gases which can be collected, led away, and burned in places arranged for that operation. This is precisely what is done by means of a *gas-producer*. Some heat is, of course, used in the producer in this process, but the same amount of heat is used in an ordinary fire for the production of these gases, without which there can be no flame. In gasworks coal is charged into retorts, which are chambers closed to the air, and heated from the outside, and in them, consequently, only the

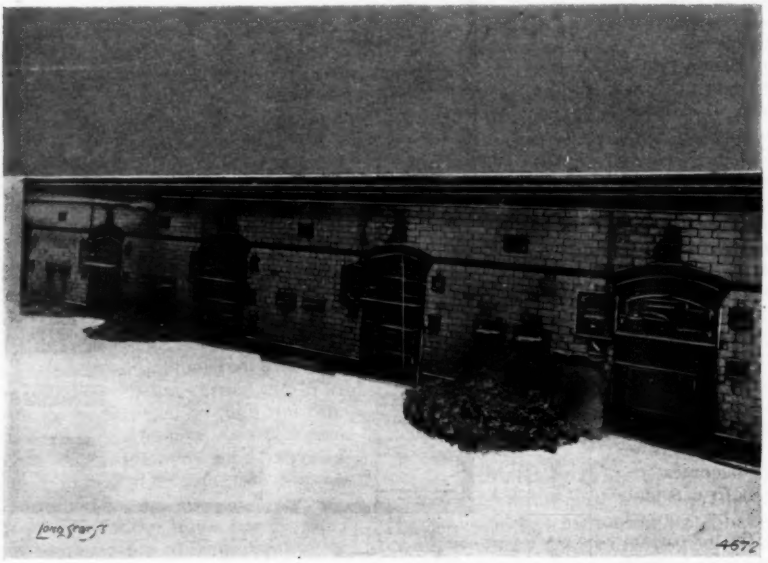


FIG. 2.—COKE-FIRED OVENS AT DUBLIN REPLACED BY GAS-FIRED OVENS.

smoke, and often to deposit soot. If we could enclose the upper part of an open fire-place and prevent the free access of air to these gases as they rise, a large proportion of them would remain combustible, and they could, with suitable arrangements, be ignited, and would burn with flame. The same holds good with regard to the carbonic oxide which is given off from the glowing fire of coke, so that it will be seen how it is possible to transform hydro-carbon gases are produced, the coke remaining unburned, so that this process is in contrast with that of the gas-producer.

It will be readily understood that much heat is lost in the case of fire-places with solid fuel through the cooling effects of too much air, and also that the degree of heat given off by the fire frequently varies according to the periods of charging it with fresh fuel.

In many furnaces or ovens fired with

coal or coke, all the heat carried away by the products of combustion is not entirely lost, because these gases pass through the structure in contact with its walls to which they impart some of their heat before they escape up the chimney—but the structure is hotter or colder according as these gases are hotter or colder. The loss of heat from excess of air is undoubted, and, moreover, there is further loss due to the fact that the fire-place must be far hotter than the rest of the structure, so that the heat of the fuel is not applied in the most economical manner.

A gas producer is thus practically an enclosed fire-place, in which the fuel is burned in such a way as to produce from it the maximum amount of combustible gas, and therefore not to obtain the greatest amount of heat in the place where the solid fuel is burned. That heat is wanted in the structure where the heating or baking process is being carried on, and by leading the gases there and causing them to burn with flame there, the desired result is produced in the proper place, and this is done without fluctuation of temperature and without smoke. The producer is placed outside the bake-house, at any convenient distance, so that neither coal, coke nor ashes need enter there. Moreover, one producer or two producers with one attendant can make gas for a large number of ovens, so that there is no stoking in the bake-house, and all stoking-room there is saved, and is available as additional floor space for its other operations.

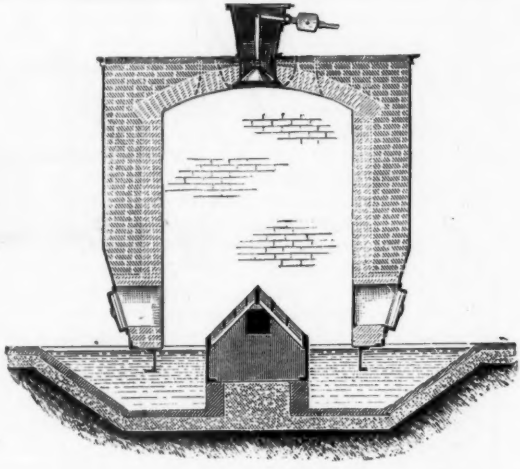
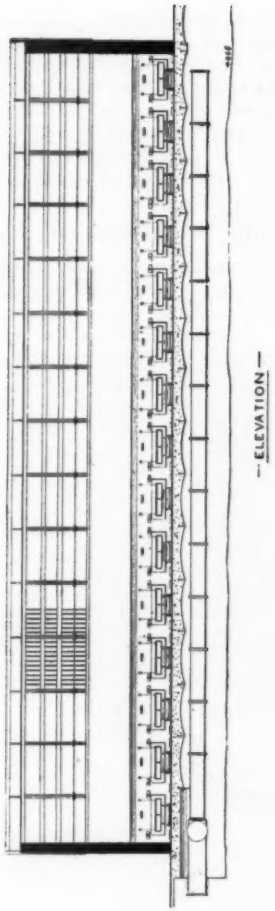


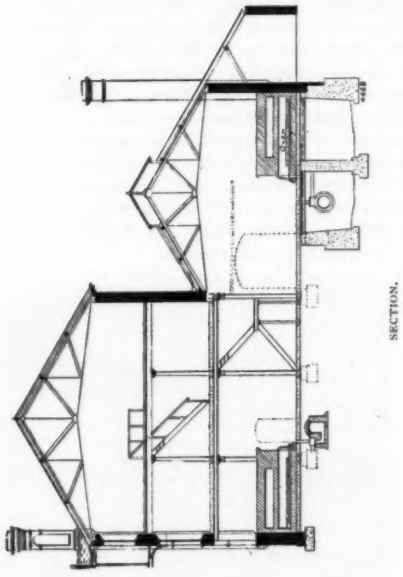
FIG. 3.—GENERAL ARRANGEMENT OF "DUFF" PRODUCER.

Description of Gas-fired Oven plant.

A wide experience of gas-firing applied to all kinds of furnaces used in industrial operations, and also long acquaintance with the construction and working of hot-air draw-plate ovens fired by coke (of which ovens they were the introducers) and of steam ovens, enabled Messrs. W. F. Mason, Ltd., to design and construct ovens for gas-firing which were successful from the start.

We give in Fig. 1, a plan illustrating the great bakery of Messrs. Johnston, Mooney and O'Brien, Ltd., at Ball's Bridge, Dublin, where twenty-five ovens fired by solid fuel were installed. These ovens are represented in the photograph from which Fig. 2 has been produced, and in it the heaps of coke will be seen at the side of





FIGS. 4 AND 5.
GENERAL ARRANGEMENT OF GAS-FIRED DRAW-PLATE OVENS FOR MESSRS. JOHNSTONE, MOONEY AND O'BRIEN, BALL'S BRIDGE BAKERY, DUBLIN.

the ovens. Many of these ovens have been replaced by the new gas-fired ovens, and gradually the whole installation will thus be altered.

In the plan, Fig. 1, the position of two gas-producers is shown. These are specimens of Messrs. Mason's well-known "Duff" gas-producer, of which Fig. 3 represents the construction and general arrangement. It is a closed iron chamber, either cylindrical or rectangular in form, built inside with fire-brick, which stands over a water trough forming the bottom of the producer. This trough has sloping ends, by which ashes are removed from time to time through the water, and at right angles across its centre there is placed the **A**-shaped grate or blast-grid of the producer. This "grate" is the distinguishing feature of this producer. It is not truly a grate, as the fuel is, for the most part, supported by the ash resting in the water-trough, but it performs the functions of a grate in distributing the air

to the fuel over a considerable area. The peculiar form of this grid gives it the power of distributing the blast evenly throughout the mass of the fuel at the centre and outwards, at the same time without allowing the escape of free air up along the surface of the brickwork of the producer lining. It is the only form of distributor as yet introduced which permits the air and steam of the blast to ascend directly upwards through the fuel at the centre of the producer, and that, while distributing the necessary portion outwards towards each side, does not force the blast downwards or horizontally outwards to the walls, or deflect it in any way from an upward direction. Undoubtedly the secret of much of the success of this producer and its ability to produce gas of good quality is found in this air distribution, and it certainly accounts for producers of this design being able to work successfully when of large size, as well as giving some of the best results when gasifying coal with a view to recovering the maximum of ammonia from its nitrogen. It is an essential condition of that problem that each particle of the nitrogen, when set free from its combination with the carbon, should be enveloped in an atmosphere of hydrogen for union, and of steam for preservation of the ammonia thus formed; and it stands to reason that the more complete is the distribution of the air and steam through the mass of the fuel, the better is the prospect of that condition being fulfilled.

There is another important consequence of this equal distribution of the air over a large area of the fuel, and that is, that it ensures a very complete combustion of the fuel, and a minimum quantity of unburned cinder-coke amongst the ashes. It is not the case that the water-trough system of cleaning the producer causes unburned coke to be brought down amongst the ashes; the percentage of such carbon there is entirely a question of the completeness of the combustion which is carried on in the producer. The attendant who goes on digging out ashes until he reaches the fuel, in order to make sure that the producer is completely cleaned, deserves to be employed as a navvy rather than as a producer man.

In Messrs. Johnston, Mooney, and O'Brien's bakery the gas is led to one range of ovens through a wrought iron tube 3 ft. in diameter, lined with fire-brick, and placed underneath the bakery floor immediately in front of the ovens. This is shown in Fig. 4, which is an elevation of these ovens. An iron tube was used because there was an already existing tunnel on that side which had been used for the tail-race from a water-wheel. On the opposite side of the bakery, as is shown in Fig. 1, and also in the section of the building (Fig. 5), where the ground is solid, the gas is led by means of a brick flue, lined with fire-brick, and built in the corresponding position along the front of the range of ovens, and just underneath the floor. Out of the main tube or flue branch pipes are led, one to the burner of each oven, and the supply of gas to each oven is controlled by means of a valve which is inserted in this branch.

The ovens are on Messrs. Mason's well-known hot air system, but have been specially designed for gas firing. They are illustrated in Fig. 6, which is in pleasing contrast to Fig. 2. Each oven is fitted with a draw-plate 13 ft. long by 6 ft. wide, running on Mason's patent slot bearings. These bearings are an improvement on ball bearings, as they are stronger and less liable to get out of order, and the running of the plate is everything that could be desired.

In the front portion of the structure of each oven a combustion-chamber is built, in which the producer gas is mixed with air which has previously been heated by being passed round the outer walls of the oven. This mixture of gas and hot air is ignited, and the resulting flame and hot gases are led down a main flue underneath the centre of the oven sole to the back of the oven, then to the front, along two side flues, and then they rise to the top course of flues, after traversing which they pass to the chimney. As is shown in the photograph from which Fig. 6 has been produced, there are five damper handles to each oven, two at each side,

and one in the centre near the top. These actuate the dampers for controlling the heat. By opening the two bottom dampers the whole of the heat may be taken away from the sole of the oven and passed direct to the top row of flues. This, combined with the fact that the crown of the oven is formed of cast-iron plates, through which the heat is very quickly conducted, places what is termed a "flash heat" at the command of the baker whenever he may require it. By opening the two top dampers, the heat

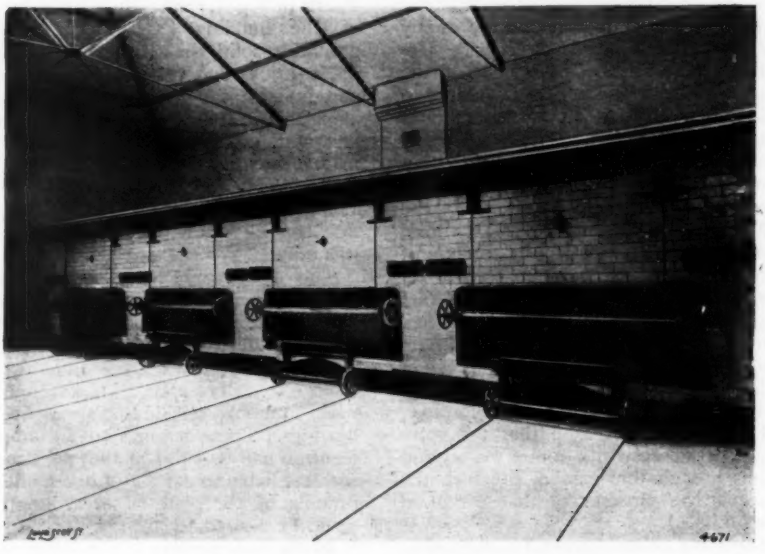


FIG. 6.—THE OVENS AT DUBLIN AS ARRANGED FOR GAS-FIRING.

may be taken off the top of the oven and conducted from the bottom flues direct to the chimney. Or by opening all the dampers the oven may be very quickly cooled down. The top damper in the centre is the main chimney damper.

In order to illustrate the possible saving in space with this system of ovens as compared with the best of former ones, Figs. 7 and 8 are added.

Fig. 7 shows an arrangement of sixteen ovens for a large bread bakery, as designed for draw-plate ovens coke-fired, with the furnace doors all at the backs of the ovens. A stoke-room 8 ft. wide was provided between the rows of ovens.

Now substituting gas-fired ovens for that arrangement, Fig. 8 shows what is the effect, a section showing how far into the bake-house room the draw-plates project.

The firing being done at the front as in the Dublin ovens, the two rows of ovens are placed back to back with one wall between them, instead of two with two furnaces, and the 8 ft. wide stoke-room is abolished. The effect of this is to throw 6 ft. additional floor space into the bake-house on each side of the central double row of ovens. This, coupled with no littering of the bake-house floor with coke or coal, and no need of space for wheeling in fuel and removing ashes, means in itself an inestimable improvement in bakery practice.

As was to be expected from the nature of gas-firing, the gas-fired ovens at Dublin

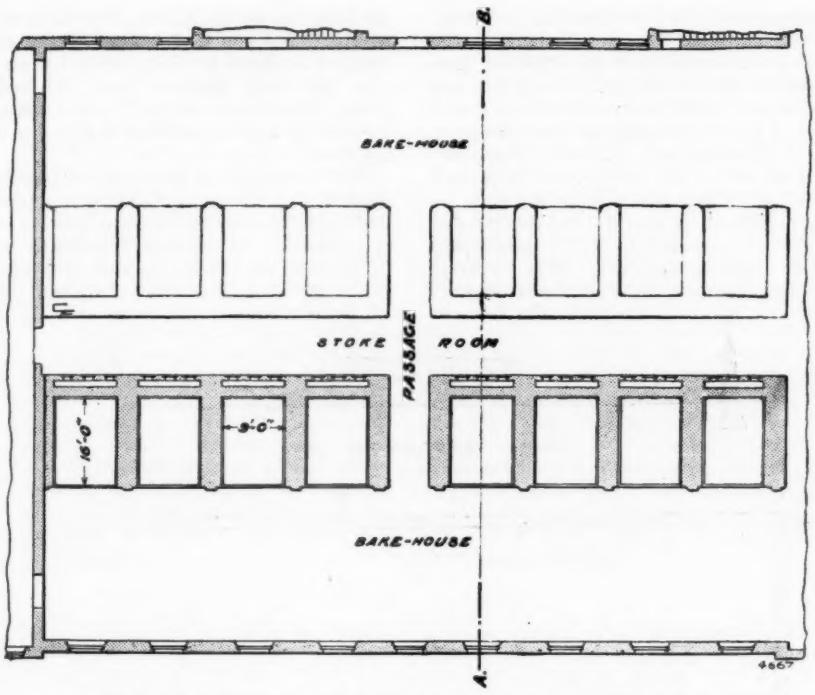


FIG. 7.—THE UNITED CO-OPERATIVE BAKING SOCIETY, LTD., CLYDEBANK, NEW BAKERY: PLAN OF GROUND FLOOR SHOWING OVENS.

have proved that by this system great evenness of baking is secured, in fact no better practical test of regularity of temperature in heating operations could be found than that which the baking of bread affords. In the Dublin ovens it is found that instead of, as is common in other ovens, some of the loaves becoming browner than others on account of differences of temperature in different positions in the oven chamber, the loaves at the front of the gas-fired ovens have exactly the same colour and appearance as the "head" loaves. The batches can be drawn to the minute, and this certainty of firing results in more rapid work, so that five batches have been baked in the time formerly required for three in the original ovens, or four in the best coke-fire draw-plate ovens. Not only so, the thorough heating of the ovens and the command of the heat are such, that an oven shut up for a period of 12 hours has been found to lose only 10 degs. Fahr. of temperature during that time, the gas having been shut off from it.

In different parts of the country prejudice is found to exist in favour of some particular form of oven, due to long practice with that form for the kind of bread used in that district; but better understanding of the subject shows that all the differences possible resolve themselves into a question of temperature and time. In Dublin, for instance, a higher temperature of oven is used than that which is employed in Glasgow, and consequently the batches are turned out in less time. Some of the "patent" loaves require an unusually long exposure to a

comparatively low temperature for their baking. While, however, it may not be so easy to secure such gradations of temperature where solid fuel is employed, and hence one style of oven is better suited for a given temperature than another, with gas-firing such difficulty disappears, the flexibility of the system being such that any desired temperature can be secured, from the lowest to the highest, and once it is secured it can be maintained with unfailing regularity. It is gratifying to note that the success of Messrs. Mason's gas-fired ovens in Dublin has induced the proprietors of a new large bakery in Glasgow to instal gas-firing arrangements, with the Duff producer and gas-fired ovens, in their new premises, and we may confidently expect that this system has a big future in bakeries of any size.

The advantages of gas-firing for bakery work are thus numerous, and chief amongst them are evidently the following :—

1. Absolute cleanliness is ensured in both the bake-house and the ovens. All dust, dirt and ashes, and the

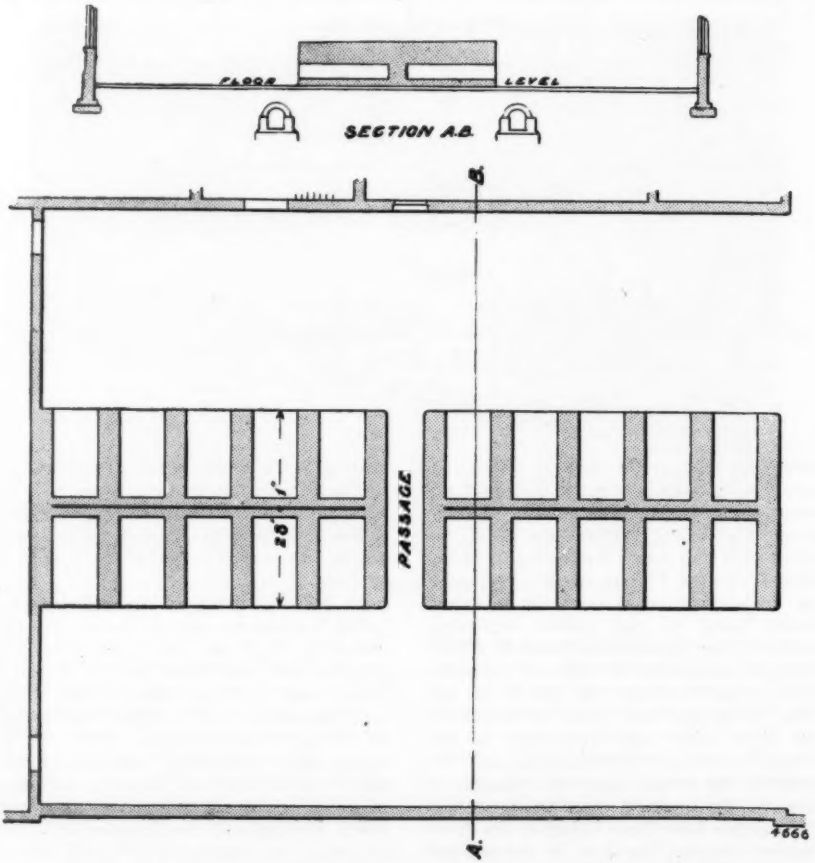


FIG. 8.—ARRANGEMENT OF GAS-FIRED DRAW-PLATE OVENS FOR THE UNITED CO-OPERATIVE BAKING SOCIETY, LTD., CLYDEBANK.

general inconvenience of stoking each oven separately, are abolished. In these days of hygienic progress this is a very great advantage.

2. They save space in the bakehouse, and thus further improve the conditions in which work is carried on.
3. The ovens are absolutely *smokeless*. This should specially commend itself to all bakers in large towns, and also to the town authorities.
4. The heat is under perfect control and regulation, so that any oven may be turned on or turned off in a few moments, and any desired temperature can be obtained and maintained with complete regularity and evenness.
5. The ovens are perfectly *continuous*, and, working without fluctuations of temperature, work more rapidly than others. There is also no need for preliminary drawing of plates or loaves to ascertain their condition.
6. The operations of handling fuel and ashes, and of firing up, are centralised, thus saving labour and preventing loss of fuel by leakage.
7. The ovens are the most economical, their repair bill is practically nil, and added to the other economies noted, they show great economy in fuel over any other system of oven firing.

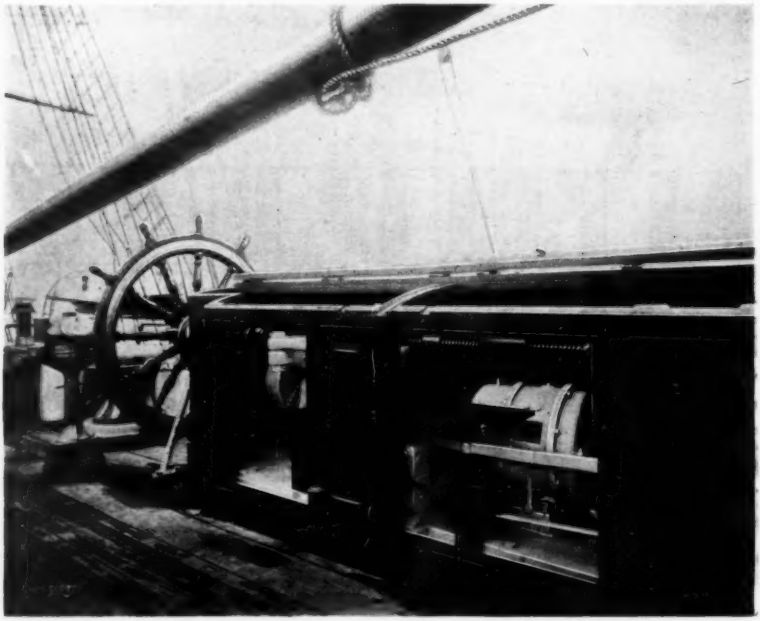
In the case of the plant described above, the old ovens were worked with coke, the price of which averaged 25*s.* to 26*s.* per ton, whilst for gas-firing a slack coal costing 11*s.* 6*d.* per ton is used. Such prices, will of course vary in different parts of the country, gas coke may come down to from 8*s.* to 12*s.* per ton, and dross or slack to from 4*s.* 6*d.* to 6*s.* 6*d.* per ton, but in addition to the difference in cost of fuel there is the saving in weight used, which is expected to work out at about ten per cent. At Dublin, one man does the stoking instead of the five formerly required.

Manufacturing Section

Electric Steering Gear on the Earl of Crawford's Yacht "Valhalla."

THE electrically-controlled steering-gear recently fitted on the Earl of Crawford's Yacht *Valhalla*, is of the type usually fitted on large yachts for hand steering, and has been only slightly altered so as to adapt it for electrical driving.

It consists essentially of a solid cast-iron frame bolted on to the deck. The upper end of the rudder post passes through the base of the frame, and carries securely keyed to it a massive cross-piece. Above this and running fore and aft is a right and left handed screw supported in the frame and carrying one right and one left handed nut, which are supported and prevented from turning by two guides running parallel with the screw. These nuts are connected by links one to each side of the cross-piece on the rudder post, and by this means the turning of the screw operates the rudder.



ELECTRIC STEERING GEAR OF STEAM YACHT "VALHALLA."

The steering wheel is large enough to be used in emergency for hand steering, and is carried on a sleeve on an extension of the screw, to which it can be connected by means of a claw clutch.

A Siemens 4-pole completely enclosed motor is arranged so as to drive the screw through several reductions of spur gearing and through a claw clutch. This clutch is connected to that on the steering wheel, in such a manner that both are operated by one lever, and only one can be in gear at a time. It will thus be seen that the screw which operates the rudder through the nuts and links, is capable of being turned either by the electric motor or by the steering wheel, but not by both at once.

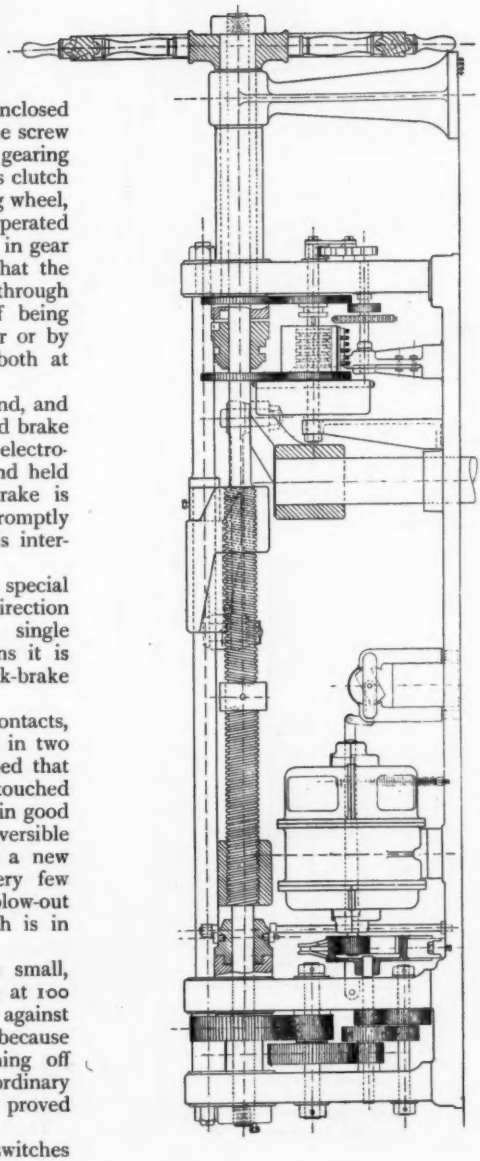
The electric motor is series wound, and is provided with a brake, pulley and brake blocks, which are held off by an electro-magnet in series with the motor and held on by a suitable spring. The brake is therefore put on and the motor promptly pulled up whenever the current is interrupted.

The motor is controlled by two special starting switches, one for each direction of rotation, instead of using a single reversing switch, as by this means it is possible to get a very reliable quick-brake action.

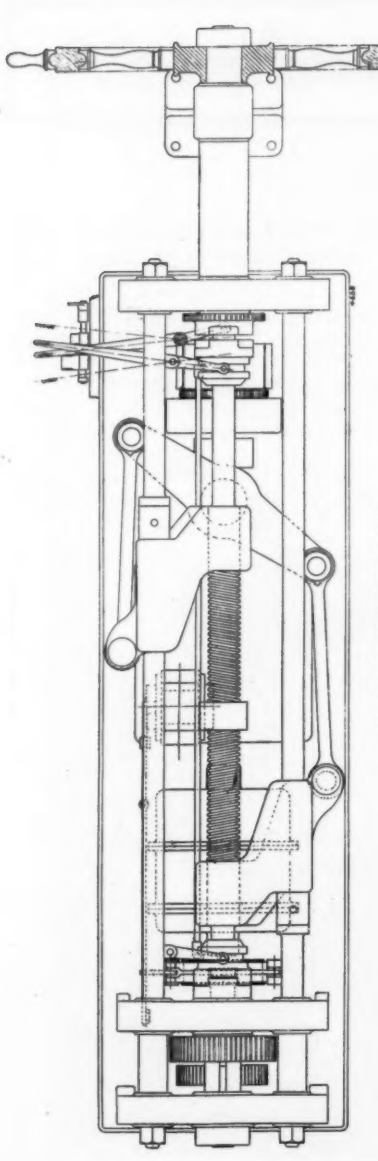
The switches each have three contacts, so that resistance can be cut out in two steps, and the contacts are so shaped that the actual contact-surfaces are not touched by the arcs, and therefore remain in good condition. The contacts are reversible and very easily replaceable, and a new contact can be inserted in a very few minutes. A powerful magnetic blow-out is provided on each switch, which is in operation on all the contacts.

Although the current is quite small, being not more than 25 ampères at 100 volts, these ample precautions against arcing troubles have been taken because of the extremely frequent switching off and on which is required in the ordinary steering of a ship. They have proved quite satisfactory in practice.

The operation of the starting switches is accomplished as follows :—



ELECTRIC STEERING GEAR : ELEVATION.



ELECTRIC STEERING GEAR: PLAN.

The two switch-arms are mounted on two pins on a metal disc and at equal distances from its centre. The disc is geared to the screw, and its motion is therefore proportional to that of the rudder. The switches have cranked arms, as shown in the drawing, which can be pushed so as to put the switches on or off, by stops on a second disc mounted concentrically with the first.

The second disc is in gear with the steering wheel, and its motion is therefore proportional thereto. The switching on or off is therefore the result of the difference in the motions of the two discs, which are proportional to that of the rudder and the steering wheel respectively.

The cranked arm of each switch is so shaped that it clears the stops on the second disc when the motion is in one direction, but engages them when the motion is in the opposite direction. This ensures that one switch only is operative in each direction of rotation.

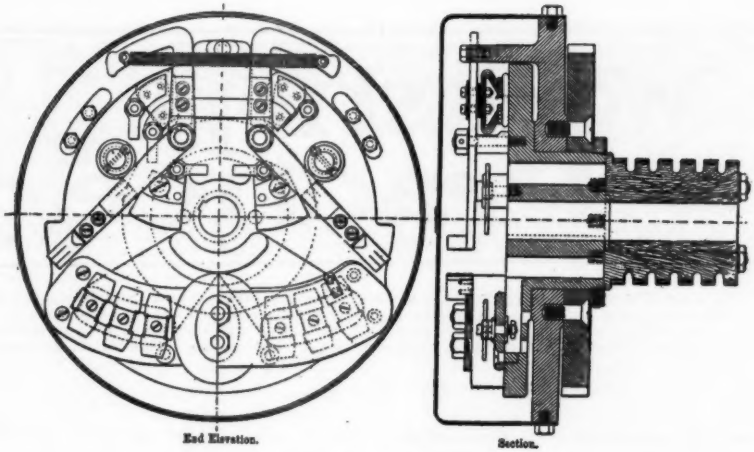
Both switches are pulled to the off position by springs, so as to get a quick break, but they are also pushed off positively by the stops, so that the breaking of a spring does not incapacitate the gear in any way, but only makes the break rather slower.

The two discs are further provided with massive stops arranged to limit the difference of their motions to little more than the amount actually required to operate the switches.

The gearing is such that twelve complete turns of the steering wheel move the rudder from hard-a-port to hard-a-starboard, a total angular distance of 80 degs.

A Geneva stop is provided on the second switch-disc, which prevents the steering wheel from turning more than twelve complete revolutions. When the Geneva-stop is reached the second disc is stopped and the first catches it up, so that the motor is automatically switched off when the extreme positions of the rudder are reached.

The trials which have taken place on the *Valhalla* have proved quite satisfactory; the control of the ship was as perfect as



ROTARY HUNTING SWITCH.

could be desired, and gave complete satisfaction to the navigating officers.

The test imposed by them, which was considered the most severe, namely, throwing the rudder from hard-a-port to hard-a-starboard while steaming full speed astern, was accomplished with ease and without excessive consumption of current.

The gear is a patent invention of the Hon. R. Brougham, put into a practical shape in collaboration with Messrs. J. S. White & Co., of East Cowes, and Messrs. Siemens Bros. & Co., Ltd., of London, who have fitted the plant on board the *Valhalla*.

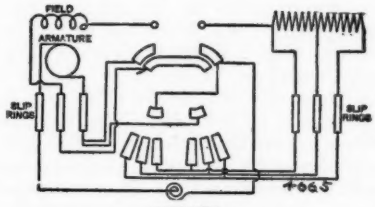


DIAGRAM OF CONNECTIONS.

Workshop Practice

The attention of Works Managers, Foremen, and those under their charge, is particularly directed to this section, which has been designed for providing an opportunity of bringing practical ideas and experiences into print. What we desire to encourage is inventive capacity and originality. Send along particulars, accompanied by rough sketches, of emergency devices, jobs which have taxed your ingenuity, etc.; they are worth recording.

❀ ❀ ❀

Repairing a Damaged Commutator.

Owing to a burst armature in a large bi-polar direct-current generator, a large hole was burned in two adjacent bars of the commutator, the intervening mica being pierced and destroyed by the arc set up. Fig. 1 shows the general shape and dimensions of the hole. The first operation was to carefully clean and tin the surface of the hole. The two bars were then wedged apart by a "bodger," and mica strips, *A B*, of the requisite size and thickness forced in. The commutator was then warmed up as much as possible by means of soldering irons, and strips of mica, *C D E F*, placed at the front and back of the hole, being kept in position by pieces of wood, *W*. Solder was then poured into the hole from a ladle, using a rough mica funnel to guide it. This method proved to be a thoroughly good mechanical and electrical one, and saved the time and cost of dismantling the commutator entirely and fitting new bars. The details of the operation are shown at Figs. 2 and 3. C. J. G.

An Improvement in Flexible Wires.

Twin flexible cords are generally used for making connections with portable electrical measuring and testing instruments. They are also used in connection with telephone instruments. It is desirable that they can be readily untwisted, more or less, when necessary. This allows some freedom in selecting the positions of the apparatus it connects. A

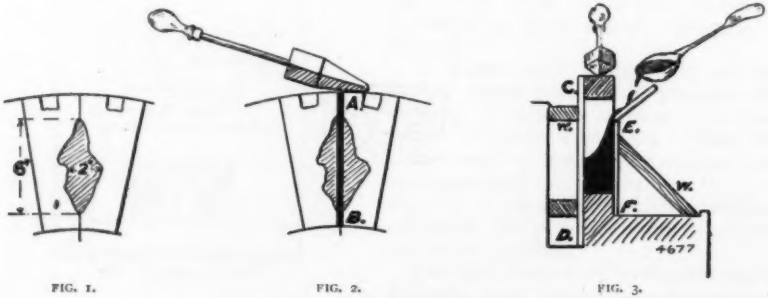
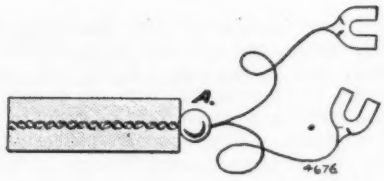


FIG. 1. FIG. 2. FIG. 3.

REPAIRING A DAMAGED COMMUTATOR.



AN IMPROVEMENT IN FLEXIBLE WIRES.

convenient way of arranging for this is to drill a hole in a round ball, *A*, the size of nut. The ball may be made of wood or ebonite, the hole being a fair fit for the cords. Then, by moving the ball *A* along the cords, the length of the untwisted parts can be increased or diminished as desired. W. W.

A Testing Arrangement for Bells and Telephones.

The accompanying illustration shows a very useful arrangement for testing bells, telephones, etc. It causes no inconvenience when not in use, occupies practically no space, all the connections can be made permanent, and is always ready for use. For the normal position the flexible cord *A C* hangs in front of the leg of a bench, where such work is generally done. When it is required for use, it is lifted up and the ends of it afford the necessary connections, as explained below.

A battery is fixed under the bench, and a hole bored in one of the legs. Around this are fixed three terminals, connected as follows :—

No. 1. To the galvanometer fixed on the wall.

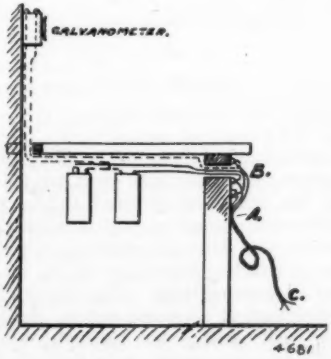
No. 2. To one pole of the first cell

No. 3. To opposite pole of second cell.

The other terminal of the galvanometer is connected to the wire that connects the cells in series.

Then attach by a holdfast *A* one yard of flexible cord. And connect the ends to the three terminals mentioned. Take off some of the covering at the other end *C*, and leave the ends of unequal lengths, this being done to prevent the ends short circuiting the battery when not in use. The ends may be distinguished by fastening coloured threads round them; then the battery end, say the white one, will be the common connection; the red one the galvanometer, and the blue the battery.

By holding the ends, one can test with the battery and galvanometer, or the battery alone, as desired. W. W



A TESTING ARRANGEMENT FOR BELLS AND TELEPHONES.

Construction of Pattern for Cast-iron Tuyère.

The special form of tuyère illustrated at Fig. 1 represents an example which gave some considerable difficulty in the foundry before satisfactory results were obtained, as all previous methods had failed to produce castings sufficiently good to meet the requirements of this particular class of work. The following is a description of the different methods of constructing the core-box used in connection with the same, and may serve to point out the solution of a difficulty, as the principle may be applied to similar work where thin sections of sand have to be supported during the process of core-making. A portion of the casting represents a series of ribs $\frac{3}{16}$ in. at the bottom, and $\frac{3}{32}$ in. at the top edge, and $\frac{3}{8}$ in. pitch, the depth from *C* to *D* being $3\frac{1}{2}$ ins. It will be readily seen that the sand at the root of

the ribs is very frail, and having very little taper it was found, in making the core in the usual way with the ribs fixed in the box, that the sand either remained in the core-box or was broken off by the slight vibration of the latter while lifting it away. The next experiment adopted was to screw the ribs in position while making the core, and then to unscrew and leave them loose, withdrawing the ribs separately, but so much time was lost in the core-shop that this was abandoned. The third experiment, however, proved very successful, and was eventually adopted. The will here be observed, for the box now represents a grid with bars $\frac{3}{16}$ in. in thickness, and 6 ins. long. It will also be easily understood the bars are stronger and more easily pared than if cut contrary to the grain. The back part of the box, *D*, was recessed to give firmness to the ribs, which were passed through the bottom of the box. The ribs were fitted so that there was very little play in the slots, and yet were loose enough to be withdrawn easily: a shoulder was cut at *A* and *B* to keep the ribs from going beyond the required depth, and to assist

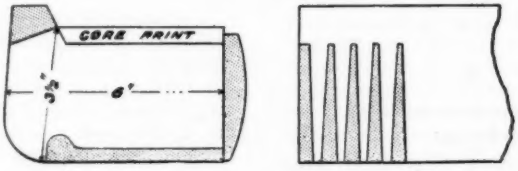


FIG. 1.

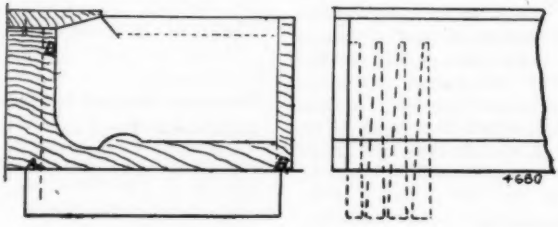


FIG. 2.

CONSTRUCTION OF PATTERN FOR CAST-IRON TUYÈRE.

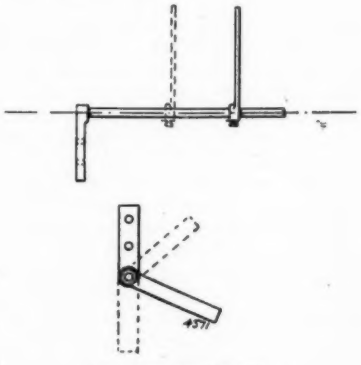
section of core-box, as shown in Fig 2, was made the required length in hard wood, with the grain of the timber running across the section from *A* to *B*. The bottom of the core-box, which in the other cases had been rough, was then planed to a parallel thickness, and lines were set off on the inside and bottom equal in width to the thickness of the ribs of the root. These were cut through as clean and true as possible. The reason for making the grain across the section in withdrawing them. The ribs being in position, and the core sand rammed in, the box was then inverted, and each rib withdrawn separately. This produced a perfect core with no mending-up necessary, this fact adding materially to the production of clean castings. The object of this description is to point out to designers how such castings can be made, whether applied to the tuyère or to any other job of a similar character.

H. D.

Adjustable Boring Knee.

The sketch shows a knee which can be easily adjusted to meet varying positions. It consists of a rod, kneed and flattened at one end for fixing to the job. Fitted to the rod, and sliding up and down it as required, is an arm, provided with a set pin at the eye for keeping it in position on the rod. The arm can rotate on the rod, so that it is an improvement on the ordinary knee, which is in one piece. This knee was made for use with an air-drill, and to suit the different lengths of drills used.

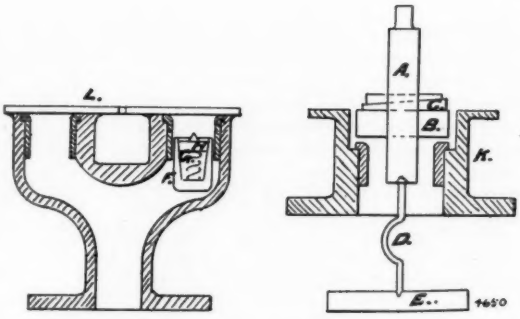
E. F.



ADJUSTABLE BORING KNEE.

Facing-up Valve Seats.

In a previous issue of the magazine I noticed a device for facing-up valve-seats in their place. Permit me to offer an arrangement invented and made by me some years ago, and which was used with perfect success as to despatch and accuracy. Valve-seats were principally safety valve-seats fitted into manhole castings. On locomotive boilers *K* is end view of casting for double safety valves, Ramsbottom type. Valves were ordinary mitre; when ground in repeatedly to keep them steam tight seats would get wider, which necessitated facing top part of bush to make seat narrower, hence the arrangement which would also do for flat valve-seats, faced up as well as if done in lathe. *A*, boring bar; *B*, cutter; *C*, wedges to keep cutter in place; *D*, piece of $\frac{5}{8}$-in. or $\frac{3}{4}$-in. round iron, bent as per sketch; *E*, plate with centre for end of bar to rest on to take weight of bar and back-lash of machine, so that cutter would not dig in. Same bar can be used for both types of safety valves, *K* and *L*; but in Fig. *L* there is a brass bush, *F*, easy fit in valve-bush; *G* is spiral spring with washer *H*, with centre to take up slack and weight of boring-bar with cutter, while end of bar enters bush as it goes down.

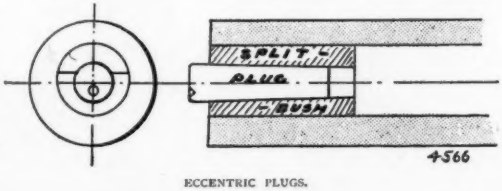


FACING UP VALVE-SEATS.

G. J. Rees.

Eccentric Plugs for Rough Castings.

Having a number of cast-iron rollers to turn, the cored holes of which were very much out of centre, the following method was adopted to meet the difficulty:—A cast-iron bush was turned, as shown in the sketch, with the hole eccentric and the



ECCENTRIC PLUGS.

outside diameter of a size suitable to the average diameter of the cored holes, the hole in the bush having a taper of 1 in 8. The bush was parted through the centre, as shown, and a cast-steel plug or centre turned to fit; the centre in the end of the latter being also eccentric, it was then hardened. The bush or bushes were inserted in one or both ends of the castings, and the amount of movement obtained by bush and plug provided for the worst cored hole. T. L. B.

Bent Rod Spoils the Vacuum.

A somewhat singular incident occurred in connection with an engine driving a 60 kilo-watt three-phase generator and some lighting dynamos situated in a private supply station. The type of engine was a single-cylinder, surface-condensing, and fitted with a so-called improved Corliss gear, governed on the cut-off; the pumps being worked by a rod from the crosshead. One evening, just as the full load was being gradually put on, there was an appreciable loss of vacuum, and as the load increased this became steadily worse, so much that the circulating pump, although working its full limit, was quite unequal to the demand upon it. Being unable at once to locate the trouble, we resorted to the expedient of flooding the condenser from the town supply. Fortunately there is ample boiler power at the place, or otherwise the effect of introducing cold feed at top load time might have been attended with serious results. The next day the condenser was tested, the piston rings examined, and the pump thoroughly overhauled, but all to no purpose, everything seeming to be in the best of condition. After some hours' useless work we discovered that one of the exhaust valve-rods had in some mysterious manner become slightly bent. This defect gave a portion of steam a direct run into the condenser, more particularly at the full load, thus causing the trouble we had been so anxiously trying to discover. DUNIELMAN.

An Improved Governor Pulley.

At Fig. 1 is shown a section of a governor pulley, fitted to a horizontal engine, and illustrates how a small detail may cause a great amount of trouble and expense. It is 8¾ ins. diameter, runs about 250 revolutions per minute, and is driven by two chain-belts, each 2 ins. wide. The oil from the cup leaked over the end of the bearing on to the pulley, until it finally reached the belt. The result was that the belts wore rapidly, commenced to rot, and caused a great deal of annoyance by slipping. To prevent this a pulley was made, as Fig. 3, and when put on proved thoroughly effective.

Fig. 4 is an enlarged section, showing the grooving on the inclined faces of the outer edges. The centrifugal force being sufficient to keep the oil on the outside edge, there would be a tendency for the oil to gather on the belt when at rest. The oil leaking from the bearing collects on the rim of the sharp ledge. When the pulley stops, some of this oil trickles down the incline, but is caught in the grooves and conveyed round the rim to the under side, where it drops off. D. S.

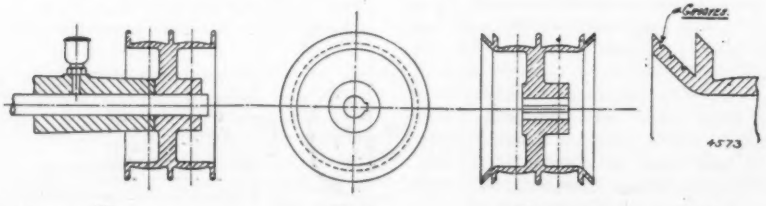


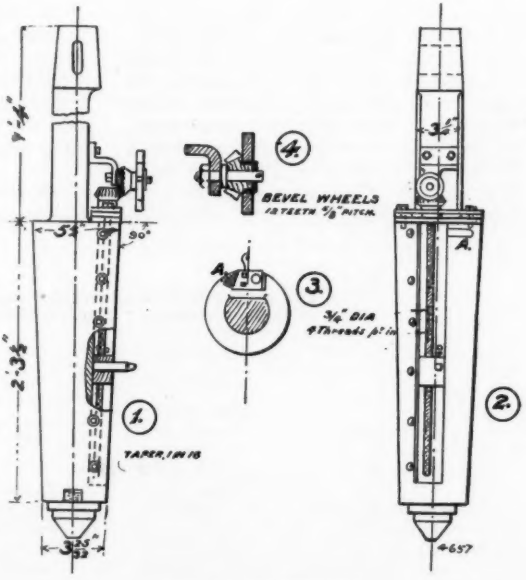
Fig. 1. Fig. 2. Fig. 3. Fig. 4.

AN IMPROVED GOVERNOR PULLEY.

Boring Bar for Propellers.

Having a number of similar propellers to bore out to a standard taper, this bar was designed for the purpose, as being quicker and more accurate than the old method. The bar is of wrought iron, the top being turned to fit the taper of the machine spindle, while the body is turned to a taper of 1 in 16. This part was turned as accurate as possible. The middle portion was turned parallel, and part of this was cut away, as shown in Fig. 3, to allow the bracket to be fastened conveniently. The bar was then set on a planing-machine table, and the slot, in which the tool-box traverses, was planed out. The depth of this slot is uniform throughout in length. The tool-box (steel) is fitted with a long feed screw, the bottom end of which is free. At the other end of the screw a collar is turned on it, which is clamped between two thrust plates bolted on to the bar. A plain portion of the screw projects above the thrust plates, and to this is keyed a small brass bevel wheel. A bracket carrying a fixed spindle is bolted on to the middle portion of bar. The other bevel wheel and the feed star-wheel (secured together by two $\frac{5}{16}$-in. pins) slips over this spindle, and a washer and split pin keep them in place. For details, see Fig. 4. Adjustment for wear down the slot is provided for by a thin steel plate and adjusting screws. The two end screws screw into the plate itself, and the others screw into bar and press against the plate. A steel centre was screwed into the bottom of the bar, and was turned up into position. A portion of the bar near the top of slot (*A*, Figs. 2 and 3) was cut away to allow for the tightening of the screws in the tool-box. The bar was found to answer in a very satisfactory manner, no "lifting" of the tool-box being observed, due, perhaps, to the careful "bedding in" it received.

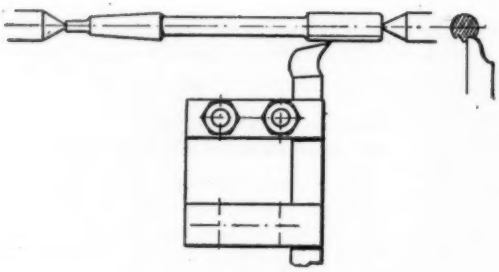
E. H. D.



BORING BAR FOR PROPELLERS.

Change in temperature causes trouble with bearings.

An awkward breakdown, causing considerable trouble and loss of time, occurred at a mill where I was recently engaged, and which may be described as an act of thoughtlessness on the part of the engineer in charge. A great deal of annoyance had been caused by the overheating of the bearings of a 100 h.p. quick-running engine fitted with white metal and ordinary drip lubricators. At the first opportunity it was fitted with forced lubrication, the white metal bearings scraped, and all the remaining parts put in good working order. The engine was situated in a small ill-ventilated place, practically underground, and comparatively cool until a short time after working, when the temperature would rise from 30 to



GROOVING SMALL TAPS.

40 degs. Having got everything ready we started running with a light load, the bearing caps well screwed down, and the load gradually increased until the full amount was reached, when we then ran about 9 hours for testing purposes. During the time the engine ran splendidly, and after the test we decided to take off the caps for examination. We found the bearings in excellent condition, and the fitter replaced the caps, screwing them down to exactly the same position. On starting again after a short holiday, during which the mill was closed, the engineer thought the nuts on cap bolts seemed rather slack, so tightened them up and started the engine. Within twenty minutes, whilst attending to other duties a distance away, two out of the three bearings had melted the white metal and scored the shaft badly. After careful consideration and a thorough examination, we came to the conclusion that the cause was attributable to the contraction during the week end which caused the bolts to appear slack, and the expansion of the metal when the engine and surroundings became heated.

H. C.

Grooving Small Taps, &c.

In making small taps and reamers much time and inconvenience can be saved in setting, etc., by using the following method. The appended sketch shows all that is necessary as regards setting. The depth of cut is regulated by the cross traverse handle, and the cut itself is made by the longitudinal traverse handle, the spindle remaining at rest. The advantages of this method are that no spindle tackle is required, and for parallel reamers or taps no alteration to lathe is necessary: but, for taper articles, one of the headstocks will need adjusting to allow for the tapering width of groove. When the diameter of the article to be grooved is less than the diameter of the centre, a piece of wood or other suitable material of correct length should be inserted between the loose headstock and the lathe carriage, to prevent the tool coming in contact with the lathe centre.

J. D. SCAIFE.

[Of course, some arrangement for dividing would have to be used.—ED.]

The guinea prize was awarded last month for the contribution "A Slack Piston Rod."

WORKSHOP QUERIES AND ANSWERS.

WILL some of our readers kindly answer the following?

Electric Motors *v.* Insurance Companies.

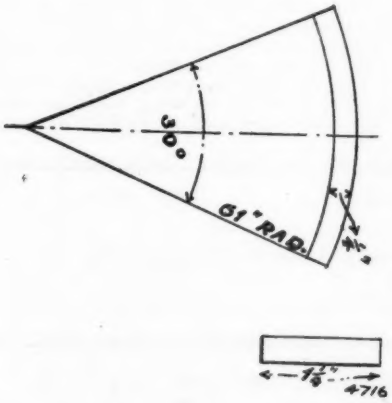
Under what circumstances do insurance companies permit the use of non-enclosed electric motors? What grounds have they for objecting to them in isolated position, free from all inflammable materials?

Q. E. F.

[We are not aware that they do; it is opposed to our experience.—ED.]

Coal Consumption.

The output of an electrical plant is 300 ampères at 210 volts. It consists of 130 b.h.p. high-speed three-crank single-acting engine, coupled direct to a 85-k.w. dynamo; Lancashire boiler with hot feed-water, burning Lancashire coal; steam pressure 90 lbs.; electric motor drives feed-pump. What should be a fair coal consumption for a 10-hour day. Q. E. F.



How can I ascertain the correct length to cut brass strips to form an angle of 30°, so that when bent to radius, as shown, the arcs, to complete a circle, will join closely without the ends having to be filed, etc.?

A. B.

Has an engine more power with a long or short connecting rod? and which is the most conducive to easy running?

R. E. H.

How are boiler flues (plain and corrugated) tested for stiffness and capability to resist collapse? Are such flues ever tested by heating to observe effects of expansion? E. H. D.

I wish to harden and temper a small metal cutting circular saw $\frac{1}{16}$ in. thick and 5 in. diam. As I have previously had a disaster, and twisted one out of shape in the hardening process, I shall be glad if some reader will tell me how to proceed?

ASPIRANT.

I wish to drill a $\frac{1}{2}$ in. hole through a piece of glass 12 in. diam. and $\frac{1}{4}$ in. thick. How am I to do it? ASPIRANT.

Lowest Cost of Motive Power.

It is generally admitted that, to reduce the stand-by losses that are unavoidable when electrical supply authorities are dependent upon purely lighting loads, the supply of current for motive power is a great help. In order to induce small manufacturers, etc., to adopt it, and to compete successfully with gas and oil engines, the price charged per unit must be low. The following particulars are those for the Manchester Corporation:—

		Per Unit.
Manchester, 1901–2	Works cost	1·15*d.*
	Total cost	1·69*d.*
Average price obtained	Traction	1·25*d.*
	Private supply	3·49*d.*
Motive power	Former charge	2·0*d.*
	Proposed new charge	1·25*d.*

The proposed charge for motive power is the same as that for electric traction, and is only 8·7 per cent. over the works cost, the effect of which upon the financial result will be of special interest.

What is the smallest percentage over the works costs that it is advantageous to sell motive power at? What are the bases on which the scale of charges for motive power are made? Q. E. F.

REPLIES.

REPLY TO H. P.

Hardening Change.

The change that actually takes place in the piece of hardened steel is that all the molecules (or small particles of steel) have so arranged themselves in the direction of their greatest length, under a gentle influence of heat, and have been so fixed by rapid cooling, thereby giving to the steel a closer and different nature. Fig. 1 represents a piece of soft steel, and under the influence of heat it gradually becomes as represented in Fig. 2.

FIG. 1.

FIG 2. 4715

This may not be so clearly seen in steel as in iron, owing, of course, to the different nature and process of manufacture. I maintain that steel, whether heated by fire or by electricity, undergoes the same molecular change; since, by rapidly magnetising and de-magnetising a bar of steel, heat is produced. The more perfectly this arrangement takes place the more perfect becomes the tool when hardened and finished. H. W.

Hardening Change.

The steel which is used for cutting tools contains carbon and manganese, and probably traces of phosphorus, silicon and sulphur. The amount of carbon varies from 1·0 to 1·4 per cent. The presence of the carbon causes the steel to be harder, stronger and less ductile, and gives it the property of hardening when heated and suddenly cooled. Manganese acts in the same way. When heated steel is plunged into water, the outside cools first and contracts on the interior. Thus the outside fibres are put into a state of tension. Afterwards the interior cools and contracts, but it is attached to the stretched exterior, and thus is put into a state of tension. Hardening may thus cause great internal stress, as shown by the cracking and twisting which occur. If the hardened steel be compared to similar steel which has not been hardened, it will be found that the ultimate strength has been greatly increased, but that the elongation has been much reduced. Hardened steel is very brittle, and a sudden shock will break it, the fracture appearing fine, close-grained and crystalline in structure. There is no well-defined yield point in the stress-strain diagram for hardened steel. If hardened steel is heated and allowed to cool slowly, the hardening previously induced, diminishes. This is called tempering; but if it is heated to 1300 deg. Fahr., or over, the whole of the hardening disappears. This process is termed annealing; it has been found that in annealed steel the carbon combines chemically with the iron, forming a carbide (Fe^3C); but when hardened this is broken up into iron and carbon. Tempered steel is intermediate between hardened and annealed steel, the carbon being partly free, and partly as carbide of iron.

In that kind of tool-steel known as "self-hardening," tungsten and chromium are introduced into the composition. They have the same effect as carbon and manganese, but produce a much greater degree of hardness; so hard, in fact, that when they are used as cutting tools without a lubricant, the rise of heat does not affect the hardness appreciably. Such tools appear to be cutting as well as when the point is red hot as when cool, so great is the hardness.

The following result of a test of ordinary and hardened steel (Unwin) shows the effect of hardending and annealing:—

Manganese Steel.	Original State.	Hardened.	Hardened and Annealed.
Tenacity in tons per sq. in.	24·71	32·69	25·17
Elongation per cent. (in 10 ins.)	29·8%	20·1%	30·3%
Stress at yield point.	16·73	——	18·76
Contraction of area per cent.	51·6%	55·3%	62·3%

E. H. D.

Circumference of Boiler Shell.

In reply to B. M. by A. W. R. in the January Number, I think our correspondent has made a mistake, as he gives the *outside diameter* × 3·1416 as the length of plate required. It should have been the outside

diameter *less* the thickness of plate, as instance,

$$7' 6'' = 90 \times 3{\cdot}1416 = 23' 6\tfrac{1}{4}.$$

Suppose plate thickness $= \tfrac{3}{4}''$,

$$7' 5\tfrac{1}{4} = 89{\cdot}25 \times 3{\cdot}1416 = 23' 4\tfrac{3}{8},$$

difference $2\tfrac{3}{8}''$

R. M.

[R. M. is correct; the *mean diameter* should be taken for all thicknesses.—ED.]

REPLY TO S. F.

American Wood Pulleys.

In reply to S. F.'s query *re* American wood pulleys, the writer has had some considerable experience with almost every make of them, and perhaps the results he has obtained in practice may answer your correspondent's enquiry. They are, as claimed by manufacturers, light, offer an excellent surface so far as the adhesion of the belt is concerned, and meet most requirements of ordinary service very well indeed. The writer has found, however, that they can seldom be depended upon for over ten years, or, at the most, fifteen years of service. It is probable that occasional attention, and possibly a coat of paint or varnish every four or five years, might materially prolong their period of usefulness; but in most cases, and without more than ordinary care, they will be found to be strained and somewhat rickety after this time. In many places, especially textile mills, it is frequently necessary to change the speed of certain machines by the use of different pulleys on the line shafting. It would naturally be expected that wood pulleys would not withstand this frequent removal and replacing for any length of time. This is found to be the case; after being taken off and put on a few times they fail to run true, the clamping bolts become bedded in the wood, and frequent tightenings are required to prevent their slipping on the shaft. From observations, I find that most American concerns to-day continue to use the common cast-iron pulley, although wood pulleys fitted with an iron boss have attained some favour. The latter are preferable to the entire wood pulley for many reasons; and, especially at extremely high speeds, offer advantages over cast-iron pulleys, though they are not as durable.

Probably one of the best solutions of the pulley question for small sizes is the light steel pulley brought out in America in the last few years. This possesses the lightness of wood as well as the permanency of iron, and is strong enough for almost any purpose; the chief objection being that small sizes cannot be obtained for a moderately large shaft, and very large sizes are not as yet available. FRAOLA.

REPLY TO "DIAPHRAGM"

In reply to "Diaphragm," I think the amount of motion referred to, *i.e.* half an inch, is entirely impracticable for one of $2\tfrac{1}{2}$-in. diameter. Further, it is inadvisable to have the central stud go through the diaphragm. The writer has had several of them in use, constructed of brass or hard rolled copper, diameter $2\tfrac{3}{4}$ ins., thickness ·0020 in., and pressure 300 to 325 lbs. These diaphragms are well supported on the back, and their motion is absolutely limited to $\tfrac{1}{32}$ of an inch. It would seem that this might be good practice. FRAOLA.

To Principals and Works Managers.

Separate copies of the Workshop Practice supplement to **FEILDEN'S MAGAZINE** can in future be supplied for the purposes of distribution in quantities of not less than six, at the rate of 1s. 2d. per dozen. Orders should be transmitted direct to the Publisher.

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❀ ❀ ❀

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Street Rly. Journ.	**Street Railway Journal**	LONDON	s.c. 50 *c.* p.a. $6
Steamship	**The Steamship**.....	LEITH	-/6
Surveyor	**Surveyor**	LONDON	-/3
Tramway and Rly. World	**Tramway and Railway World**	LONDON	1/-
Westn. Electn.	**Western Electrician**	CHICAGO	10 *c.*
Zeitschr. Vereines Oster. Ing. und Arch.	**Zeitschrift des Oesterreisches Ingenieurs und Architecteten-Verein**	VIENNA	60 *h.*
Zeitsch. Elektrotechnik.	**Zeitschrift fur Elektrotechnik**	VIENNA	p.a. 30 *f.*
Zeitsch. Elektrochemie	**Zeitschrift fur Elektrochemie**	HALLE À S., GERMANY	4 *m.* per qr.

Most of the above mentioned publications can be obtained on application to Messrs. Williams & Norgate, Henrietta Street, Covent Garden, London, W.C.

MATERIALS AND MEASUREMENTS.

Method for Testing Oils and Metals for Bearings.

In the course of some experiments upon friction, a new method for testing oils and metals for bearings suggested itself to Mr. G. Dettmar, a German engineer. The writer first describes the apparatus used, and then enters upon a detailed discussion of the system itself. From previous trials, Mr. Dettmar had formulated the following laws bearing upon the variations of the co-efficients of friction: (1) at constant temperature and bearing pressure, the co-efficient of friction increases proportionately to the square root of the shaft speed, and frictional work is proportionate to the one-fifth power of the speed; (2) at constant temperature and shaft speed, the co-efficient of friction is inversely proportional to the pressure of the journal upon the bearing, so that the work lost by friction is independent of the pressure as long as this does not exceed a maximum value, ranging from 30 to 40 k.g. per square centimetre, according to the nature of the oil; (3) at constant pressure and shaft speed, the co-efficient and the frictional work are inversely proportional to the temperature of the bearing. The writer then proceeds to show how far these theoretical laws have been verified by actual experiment, and, finally, to compare the results obtained by Mr. Dettmar with those of Prof. Martens, of Charlottenburg, and Gen. Petroff. The systems of Mr. Dettmar, Prof. Martens, and Gen. Petroff exemplify three different methods of determination, and it is interesting to compare the results obtained thereby, so far as this is possible. Mr. Dettmar shows that the co-efficient of friction, for a given pressure and temperature, is proportional to the square root of the speed, the curve representing this condition being parabolic. Examination of the results published by Prof. Martens show that this law applies approximately to oil of every kind, and the trials of Gen. Petroff also confirm this law. The second law of Mr. Dettmar, stating that the co-efficient of friction varies in inverse ratio with the pressure, is represented by an equilateral hyperbola. The investigations of Prof. Martens indicate the approximate correctness of this theory, but it may be added that the lower branches of these hyperbolas rise for pressures of about 40 k.g., and between 0 and 160 k.g., take a final curve of U-shape. No results are found in the records of experiments by Prof. Martens relative to the influence of bearings upon friction. His form of apparatus, however, is quite suitable for such investigation, which is of sufficient importance to justify further investigation. Gen. Petroff has made theoretical inquiry as to the heating of bearings, and according to him the increase of temperature is directly proportional to the square of the journal speed, or inversely proportional to the co-efficient of friction, varying with the conductivity of the metal, its specific heat, and other physical characteristics. The law of Mr. Dettmar, which attributes to the co-efficient of friction, variations inverse to those of temperature, is equally shown by the experiments of Prof. Martens and Gen. Petroff to be practically correct. In conclusion, the writer says that the investigation of Mr. Dettmar, conducted with simple and inexpensive apparatus, serve an eminently practical purpose, and that the results obtained are in substantial accord with those of experimentalists whose qualifications are thoroughly recognised. — **Pierre Breuil,** *Le Génie Civil, Dec. 13, 1902,* pp. 105-107.

An Experimental Laboratory Canal.

With the object of obtaining information as to the forces exerted by water in movement upon the bed and banks of a watercourse, and to ascertain the mode of action of such forces, as well as the reactions caused by them, an experimental canal has been constructed at the Technical Institute, Carlsruhe. The canal is erected on the floor of a room, 25·71 m. long by 7·44 m. wide by 2·90 m. high, and of which it occupies nearly the entire length. This model watercourse is formed of sand and other materials in a wrought-iron trough supported by joists, and its gradient may be varied as desired, from 0 to 1·50. Suitable arrangements are made for the supply of water and sand during experiments, and measuring apparatus is provided for ascertaining the volume of water discharged, and the quantity of sand carried away by the water. The trough is accessible on each side, and its width is limited to 2 m. so that it may be easy for any part of the surface to be reached by the hand. The depth was fixed at 40 c.m., a dimension which is quite suitable for trials intended to throw light upon alterations of the bed. The thickness of sand resting upon the bottom of the trough is 10 c.m., but the bed may be increased in thickness in places by sand carried along by the flow of water. In addition to tests of the kind mentioned, experiments are contemplated upon the production of waves, and upon the effects produced by small streams of water. The principal materials employed in the course of experiments are washed and sifted sand of different descrip-

tions, and small canvas bags filled with granules of lead. In certain trials it is necessary to make use of sand of distinctive colour. Embankments and regulating works are represented by the bags of lead, and for the purpose of avoiding the formation of salts of lead, which rapidly destroy the material, the bags are soaked in an ammoniacal solution of oxide of copper. Obstacles such as quays, bridge piers, and other masonry constructions are represented by squared blocks of wood weighted with lead. The article contains a full description of all details of this interesting apparatus, together with several sectional drawings and photographic views. The total cost of the installation was about £780.—**R. Bischoffsheim,** *Le Génie Civil, Jan. 24, 1903,* pp. 203-203.

CONSTRUCTION.

The Mississippi River Bridge at Thebes.

THE large cantilever bridge under construction across the Mississippi River at Thebes, Ill., which was begun last January, is making satisfactory progress, and it is the expectation to have it completed early in the spring of 1904. The purpose of the bridge is to form a connection between the Illinois Central and Chicago and Eastern Illinois railroads on the one side, and the Missouri Pacific and the St. Louis South-Western on the other, all of which are interested in the bridge company. One reason for placing the bridge at the particular point selected was because of the good bottom bed-rock, being quite near the surface, and therefore obviating great foundation depths for the piers. Another reason was because of the high bluffs on both sides of the river by which long-approach viaducts were avoided. Aside from its being the largest bridge under construction in the United States at the present time, the Thebes bridge is especially notable by reason of the nature of its approaches, which are to be entirely of concrete. Of the approaches, that on the east side consists of the east abutment, five arches of 65 ft. clear span, and four supporting piers; the west end of the west arch is carried on a buttress forming part of the bridge pier. The west approach, beginning with the west end, is similar to the east approach, there being the same number of 65 ft. arches. But there is an additional arch of 100-ft. span at the east end of this approach adjoining the bridge proper. The superstructure is composed of two fixed spans, four cantilever arms, and three suspended spans, as follows: The central or channel span, which is 671 ft. long, is made up of a suspended span 366 ft. centre to centre of end pins. On each side of the channel span is a fixed span 521 ft. 2 ins. long. And lastly the shore spans, consisting each of a cantilever arm and a suspended span of the lengths given above. The spans and panels are so arranged that only two lengths of panels are used, viz. 32 ft. 6⅞ ins. in the two fixed spans, and 30 ft. 6 ins. in the centre span and the two shore spans. The total length of the bridge proper is 2,750 ft. 4 ins., and of the entire structure, including earth work and masonry approaches, 3,907 ft. It is a double-track design, with 28 ft. clearance between trusses. The height of the fixed spans is 75 ft.; of the suspended spans 55 ft.; and of the cantilever arms 50 ft. at the ends. The height of the bottom chord is 65 ft. above high water and 103 ft. above low water, which is zero on the U.S. gauge at Gray's Point. The superstructure is carried upon six piers, the first and last of which, as already mentioned, support the ends of the adjoining arches of the respective approaches. The piers are founded on bed-rock, all by means of pneumatic caissons, except No. 6, which is founded in open excavation. The estimated cost of the entire work is 2,600,000 dols., apportioned as follows:

Superstructure	$1,300,000
Substructure (main bridge) ...	540,000
Concrete approaches	270,000
Earthwork approaches	280,000
Engineering and contingencies ...	210,000
	$2,600,000

—*The Railroad Gazette, Vol. XXXV., Jan. 9, 1903,* pp. 20-22.

Calculations for Masonry Bridges.

THE method proposed by Professor W. Ritter, of l'École Polytechnique de Zurich, based upon the theory of elastic deformation, the application of which to masonry construction has been fully justified by the investigations of the Austrian Society of Engineers in 1896, has thrown a new light on the question of calculations for masonry bridges. Explaining this new method in a few words, it may be said that Professor Ritter regards a masonry bridge of several spans as a continuous arch fixed upon elastic piers, and he solves the problem by the aid of the ellipse of elasticity in a manner at once simple and precise. The method is fully expounded in this article, and an example is calculated, so that its application may be clearly understood by the reader. No general conclusions are drawn by the writer from the results obtained by this calculation, as his only object has been to make

the exposition of the method perfectly clear, and to show the advantages it offers for the easy solution of the most complicated problems relating to the strength of materials. —**H. Lossier,** *Le Génie Civil, Jan. 3, 1903,* pp. 153-156.

Shop Construction.

THIS article is the fifth of a series dealing with modern manufacturing premises, and it is concerned with various methods of floor construction, varying from the almost primitive "dirt floor" of the forge shop to the close-jointed, smoothly finished floor of the drawing office. Those more particularly described are such floors as are necessary in the modern machine-shop, forge shop, iron foundry, etc., and these are divided into the following classes :—(1) those composed exclusively of earth ; (2) those composed of earth and concrete ; (3) those of stone and concrete ; (4) those of stone or bricks ; (5) those of wood supported by iron beams ; and (6) those composed entirely of wood.—**Oscar E. Perrigo,** *Machinery, Feb. 1903,* pp. 290–293.

IRON AND STEEL.

Casting a High-Explosive Shell.

THE Isham shell, designed for carrying large charges of a sensitive high explosive, such as explosive gelatine, affords an example of the quality of metal it is now possible to cast. It consists essentially of a shell divided into compartments through which runs a central column which gives rigidity to the shell, and permits of making the walls much thinner than the ordinary armour piercer, thereby increasing the carrying capacity. Others have proposed diaphragm or compartment shells, but Mr. Isham is the first to demand that the whole shell should be cast in one piece and that the compartments should be of definite size, based on a mathematical formula. The shell is 59 ins. in length, with a diameter at the bourrelet of 11·98 ins. To the rear of the bourrelet, to a point just forward of the rifling band, the shell is turned to 11·80 inches, to allow for any possible expansion of the walls under abnormal powder pressures. The pattern for the shell is made in the usual manner, and leaves an impression in the sand the shape of the exterior of the shell. This mould is then baked. A number of cylindrical cores corresponding to the number of compartments desired are then placed in the cavity formed by the pattern of the shell. These cores, which are made of sand and other materials, have projecting from opposite sides of each two handles which serve to hold them in place, and also form the charging holes of the finished shell. The cores are placed about ½ in. apart through the length of the shell, so that when the metal is poured in and the shell is formed, the divisions are in one piece with the shell walls. These cores are afterwards shaken out of the holes formed by the handles. The casting is annealed for two weeks, when it is taken from the furnace and its exterior is turned to exact dimensions, the interior of the compartments in the meantime being partially filled with steel punchings and other abrasives, so that by the time the exterior of the shell is turned the compartments are perfectly smooth and highly polished inside. The charging holes are now bored, tapped and stopped with wooden plugs. Each chamber is tested separately to about 5,000 pounds to the square inch by hydraulic pressure, under which any cracks or flaws in the metal will instantly show by the water either pouring through or escaping in the form of fine spray. The interiors of the compartments also are inspected by means of an electric light and a small mirror.—**G. H. Powell,** *American Machinist, Jan. 24, 1903,* pp. 49–50.

Armour Piercing Projectiles.

IMPROVEMENT in the manufacture and treatment of steel has rendered it possible to make cast-steel projectiles which can penetrate face-hardened steel. The modern projectile is composed of steel containing carbon, associated with one or more of the following metals :—nickel, chromium, manganese and molybdenum. Typical proportions of elements other than iron in shells which are air-hardened are—carbon 0·80, silicon 0·2, sulphur 0·04, phosphorus 0·04, manganese 0·12, nickel 2·00, chromium 2·00 per cent. Cast-steel projectiles are cheaper than forged-steel, although the efficiency of the forged exceeds that of the cast. In present-day methods of hardening, three mediums are used, viz., water, oil, and air. These mediums differ in intensity of action, and the choice of the method to be used is determined by the composition of the material to be hardened. Each medium may also be varied—in temperature in the case of water and oil, and in pressure in the case of air. Carbon steels, are, as a rule, hardened in water, or partly in water and partly in oil ; nickel steels in water, in oil, or in air under pressure ; chrome-nickel steels in oil, or in air under pressure ; and steels having self-hardening properties by simply heating and allowing to cool in air. The use of the pyrometer for registering the quenching-temperature is mentioned in this

paper, and curves are given showing the rate of heating projectiles and cooling them in different mediums. It would be very useful to obtain, if possible, a table of hardness according to the quenching-temperature; and it may be expected that, with the same material quenched at different temperatures in the same cooling medium, such a table could be obtained by ascertaining the compression, in tons per square inch, of test-pieces so treated. The subject of testing projectiles after hardening is also dealt with, and the tests applied to English and American armour-piercing shells are described. Calculation of the internal stress needed to produce such fracture in the head of a projectile as often occurred spontaneously, shows the necessity for such tests. The remainder of the paper deals with the efficiency of armour-piercing projectiles, and contains a brief history of the progress and development of armour-plate.—**David Carnegie,** *Proc. Inst. C. E., Session 1902-3, Paper No. 8, read Feb. 10, 1903.*

Briquetting in the Iron Industry.

THE author of this paper says that the subject of briquetting has been investigated by him for the last eight years. There have been many failures, with sometimes little prospect of ultimate success. As time has slipped away, the field where briquetting, if done successfully, would prove an important economic factor has opened out to vastly larger dimensions than it had eight years ago. Already the great precious metal ore smelters of the country are using briquetting machines to force their flue dust and flue ores into blocks. But the iron men have been more sceptical. The opportunities for demonstrating that the work can be successfully done in this field, have been more difficult to obtain. But the time has come at last when a practical demonstration is about to be made. The non-success of briquetting in the past has been due to the lack of proper machinery, and to the facts that the cost of binder was too high, and that operators were generally lacking in a thorough understanding of the subject. The bonding agent that can be successfully used with precious metal concentrates or flue dust from the smelters cannot be successfully used with anthracite clum, and the binder used in briquetting the latter cannot be used in briquetting iron flue dust or fine iron ores. Adjustability of pressure is also essential, as different materials require varying pressure, ranging from 2,000 to 18,000 lbs. per square inch. One main difficulty attending briquetting is that the tiny particles of iron flue dust are rounded by being whirled about by the blast, until each particle becomes as round as a marble. In addition to this, each little piece of ore is covered with a greasy carbon coating which seems to counteract the effect of a binder. For these reasons it has been difficult to find a binder that would give a briquette with all the conditions we were looking for. The difficulties may, perhaps, be better realised when it is known that the requirements call for a briquette that shall be hard and durable; waterproof; low in moisture; able to stand long transportation in open cars; not unduly refractory or liable to decrepitate or become dust again; and the binding agent must not injure either the lining of the furnace or the quality of the iron produced. The briquettes must be produced within a reasonable length of time and the operation must be automatic, in that the material must not be handled from the time it leaves the dust bins until the finished briquette is produced. Moreover, with all of this, the cost must be moderate, in order that there shall be practically no additional charge or expense to the furnace burden. After relating the history of various attempts to arrive at a satisfactory solution of the problem, the author says that the point has now been reached where a patent binder and drying apparatus give a continuous process for the briquettes from the flue dust bins to the finished briquette in cars or storage bins; the whole operation taking about half an hour. By briquetting of the flue dust and the consequent reduction of the percentage of fine material used in the furnace, furnace owners could make considerable savings. Even greater things can be accomplished by briquetting. It is quite possible to briquette the fine ores at the mine. After first drying the material and driving off the moisture, then pressing the fine ore into blocks, the raw material can be brought direct to the furnaces in this district as lump ore in bricks that are waterproof and that are abundantly able to withstand the rough usage essential in transportation. By this means all of the evils that must now be contended with arising from the use of fine ores, can be absolutely done away with.—**Henry S. Mould,** *Eng. Soc. of West. Pennsylvania, Vol. 18, No 8,* pp. 413-424.

PRIME MOVERS.

Janson Water-Tube Boiler.

EXAMINING the contents of the report submitted to the British Admiralty by the Boiler Committee appointed for the purpose of ascertaining facts about various types of water-tube boilers, it will be

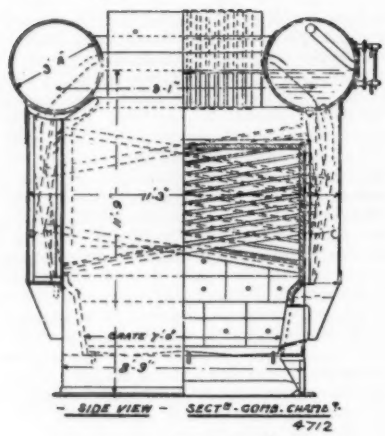


FIG. 1

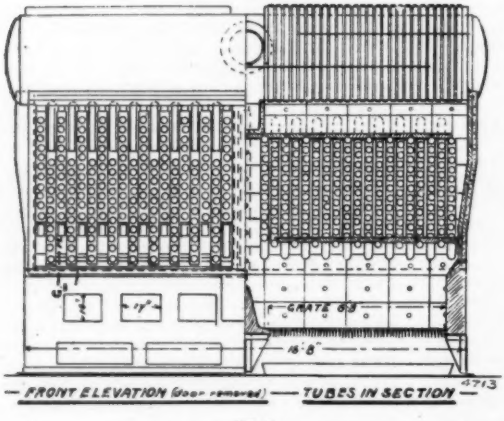


FIG 2.

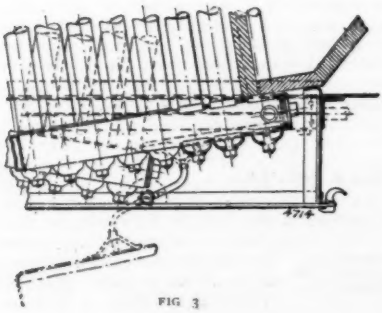


FIG 3

found that some 36 different designs and makes were under consideration. Only a few of these, however, were investigated more thoroughly when in service. Among those enumerated, three were of American design, viz.: the Babcock & Wilcox boiler, the Hohenstein, and the Janson. The first one named is well known, and needs no description, and with regard to the Hohenstein, some very extensive experiments and trials have lately been conducted by engineer officers of the United States Navy, the results of which are published in the 1902 Report of the Engineer-in-Chief. It may therefore be of interest to the readers of this magazine to also know the general features of the last-named boiler, designed by Mr. Ernest N. Janson, of the Bureau of Steam Engineering, Washington. As the present design shows in Fig. 1, the tubes have an incline of from 8 to 10 degs., due to which, looking transversely, the tube surfaces of the alternate elements almost wholly cover one another, which, as a means of baffling the gases, is of great importance, when it is considered that the gases of combustion travel across the tubes from side to side, being retarded at each and every exit by tubes running in opposite directions (the gases in that way being thoroughly beaten up). As shown in Fig. 2, the headers with their tubes are clear of one another, thereby providing for any one tube or element being withdrawn, in case of damage, without disturbance to adjoining elements. With this arrangement is also gained larger openings between the tubes and headers for the insertion of cleaning tools, and increased facilities for a thorough cleaning of any part of the boiler from the firing side. The complete absence of any return bends in the generating tubes insures a direct and very rapid circulation of water and steam, clearly indicated by the arrows shown in Fig. 1. The top and bottom bafflers, having a direct support on the tubes, and being composed entirely of fire-brick, will remain intact, no distortion being apt to occur owing to the absence of any perishable attachments. In case of damage they are easily replaced. Drain and bottom blow-off connections are attached to the large square tubes placed at the middle of each drum, which tubes also act as intermediary supports to take the weight in conjunction with the saddles, built in the casing at each end. When the boiler

is of great width, by the leaving out of a few tube elements in the middle, or at either side when of a narrower type, a fair-sized combustion chamber may readily be provided for. Of course, by doing this, some portion of the heating surface is sacrificed, but this may well be done, considering the manner in which the gases play over the tubes, rendering the whole heating surface efficient. Fig. 3 shows the details of the headers and tube caps, which are all entered through the hole at the bottom of each header, which is afterwards closed with a brass plug. The doors closing the openings, through which the boiler is cleaned, are shown with a pipe attachment for blowing off the soot with steam. All these doors open and close at the same time when turning the connecting pipe. All the lower headers are connected by means of short pipes between them at the bottom for the purpose of drainage only. This boiler is particularly well adapted for the attachment of a hot-air apparatus, either on the Howden or Ellis and Eaves system; being placed between the drums in the uptakes, no additional space, outside of what the boiler already occupies, is required. Constructively the boiler is quite simple, the headers all being of a square, straight form, and the tubes all of the same size and of a large diameter. This being so renders its manufacture well within the capacity of any well-equipped shop. Besides the recognised advantages of using large diameter tubes for water-tube boilers, it follows that the number of parts necessary to be handled at the time of examination and cleaning are reduced to a minimum, and for that reason work in connection therewith much facilitated. Appliances for burning liquid fuel may readily be attached with either front or side connections. As this boiler has not been tried on a large scale, it is now only possible to note some of the mechanical points of interest:—(1) Easily manufactured; (2) lightness; (3) large, straight tubes; (4) wrought steel all through; (5) cleaning possible from firing side, accessible for repairs and examination; (6) all tube joints expanded, metal-to-metal joints in caps; (7) rapid circulation and large water reserve; (8) complete system for baffling gases with non-perishable bafflers. —*Proc. Am. Soc. Naval Engrs., 1902*, pp. 1192-7. (*A.*)

Large Stop-Valves for High-Pressure Steam.

REFERRING to double-beat or equilibrium valves, used in marine engines, the writer says it is notorious that such valves, when shut, often pass enough steam to drive a ship half-speed. However carefully the two valve faces are fitted, one valve will bear a shade harder than the other, and the system will inevitably leak under pressure. Under the influence of increased temperature the valve-box goes out of shape; the pair of valves become distorted; the seats are no longer circular, concentric, or parallel to each other; the distance between the seats no longer equals the distance between the valves; and the apparatus is bound to leak. It may sometimes happen that in small valves with powerful closing gear sufficient force can be exerted to jam the parts together, in which case the lighter the valve can be constructed the better. But light construction is out of the question for large stop-valves to stand high steam-pressures, and recognising the futility of employing infinite power to overcome irresistible force, engineers have cast about for other means of manipulating large valves. The author then describes a flexible type of double-beat valve which has been used with considerable success in marine work. The larger valve consists of a flexible disc of hard-rolled bronze, the smaller valve being solid and of the usual type. The distance between the valve seats is slightly greater than that between the valves. Consequently, in closing, the flexible valve engages its seat first. The solid valve is then pressed home on its seat by the unbalanced steam-pressure acting on the central area of the larger valve, assisted by the handling gear. Any distortion between the valves and seats is thus taken up by the flexible disc, which readily accommodates itself to its seat, leaving the smaller solid valve free to bed itself in its own seat. The handling gear has only the difference to overcome, and the combination forms an almost ideal equilibrium valve. The success attending the adoption of the flexible disc in double-beat valves led the author to the design of an improved screw-down valve with a single seat. In this type the flexible seat consists of a thin annular disc of hard-rolled bronze, the inside edge of which forms the actual seat. A junk ring secures the flexible seat, and provides an abutment underneath to prevent undue distortion of the seat: it also becomes a back-pressure seat in the case of self-closing or screw-down non-return valves. The exact thickness of the flexible seat depends on the amount of unsupported lip that can be allowed, and this again is limited by the size of hole for the cover. Generally, however, experience proves that the thinner the seat the better; anything between 16 and 22 S.W.G. being ample in most cases.—**J. Hamilton Gibson,** *Proc. North-East Coast Inst. Eng. and Shipbuilders, Dec. 1902.*

Efficiencies of Riveted Lap Joints.

AN inspection of the published tables of riveted joints will show a bewildering array of efficiencies, based on a great variety of assumptions. Such tables are suitable for use in designing new boilers, where the quality of materials, pitch, &c., may be selected to give maximum efficiency. They are not usually suitable for existing boilers, where among other things the pitch may vary widely from that of maximum efficiency, and the rivets be of almost any diameter for a given thickness of plate. For use in existing practice, tables are submitted, covering both single and double-riveted lap joints of plates from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in thickness, rivets from $\frac{1}{2}$ in. to 1 in. in diameter, and pitches varying by sixteenths of an inch from $1\frac{3}{4}$ in. to $4\frac{3}{4}$ in. The following are the formulas by which the efficiencies are calculated :

SINGLE-RIVETED JOINTS.

$$\text{Efficiency of plate} = \frac{P-h}{P}$$

or

$$\text{Efficiency of rivets} = \frac{38{,}000\ a}{60{,}000\ P \times t}$$

DOUBLE-RIVETED JOINTS.

$$\text{Efficiency of plate} = \frac{P-h}{P}$$

or

$$\text{Efficiency of rivets} = \frac{2 \times 38{,}000\ a}{60{,}000\ P \times t}$$

In which formulas
P = pitch of rivets in single row,
h = deduction for rivet-hole = diameter cold rivet + $\frac{1}{8}$ in.,
a = area of rivet after driving,
t = thickness of plate,
38,000 = shearing strength of iron rivets,
60,000 = tensile strength of steel plate.

Of course, the smaller of the two efficiencies (that of plate or rivets) determines the strength of the joint.

The pitch for maximum efficiency can be determined by the following formulas :

SINGLE-RIVETED JOINTS.

Strength of plate $(60{,}000\ (P-h)\ t)$ must equal strength of one rivet $(38{,}000a)$, whence

$$P = \frac{\cdot 633\ a}{t} + h$$

DOUBLE-RIVETED JOINTS.

Strength of plate $(60{,}000\ (P-h)\ t)$ must equal strength of two rivets $(76{,}000\ a)$, whence

$$P = \frac{1\cdot 266\ a}{t} + h$$

The tables show clearly that the commonly used efficiencies of ·56 for single-riveted and ·70 for double-riveted joints, require carefully proportioned joints, and that the majority of joints fall considerably below those figures ; also that the larger the rivet in proportion to the plate thickness, the better the joint, as a rule.—**C. G. Robbins,** *Power, Jan. 1903*, pp. 10–12.

Manchester Steam Users' Association : Report for 1902.

IN his annual memorandum, the chief engineer again directs attention to steam pipe explosions, showing that such failures may sometimes be due to the results following the access of steam to cold water of condensation in part of a pipe system. Under the heading of "grease in boilers," he makes some useful remarks on the subject of scale in steam boilers, and then enters upon a series of memoranda upon boiler efficiency and kindred matters. Experiment shows that those boilers are the least efficient in which the supply of air to the furnace is the largest. Special attention paid to this point showed that the amount of heating surface, which is generally thought to be the most important factor as regards performance and efficiency, is practically speaking of secondary importance. Experience shows that perfect combustion cannot be attained in practice with less than 14 lbs. of air per pound of fuel, but with badly worked fires the waste gases may be thirty or forty times the weight of fuel burnt. Excess of air means reduction of flame temperature, and consequently less heat transmitted to the water. In fact, if double the proper amount of air be admitted at the furnace, heat wasted up the chimney will be increased by about 150 per cent., and the efficiency and duty of the boiler will be lowered by 15 per cent. Air leakage through the brickwork of boilers is another question to which attention is directed, such leakage frequently amounting to as much as 4 lbs. per pound of fuel burnt. Incomplete combustion generally accompanied by smoke production is also a cause of reduced efficiency. Every pound of carbon incompletely burnt to CO produces only 4,340 B.T.U., instead of 14,450; and if all the coal were incompletely burnt the maximum efficiency would be only 30 per cent of what it should be. In practice the ratio of incompletely to completely burnt fuel is only a "few per cent.," but far greater losses can be incurred by bad stoking with excess of air than too

little. There is therefore no harm in aiming to attain perfect combustion, as smoke at once reminds one that combustion is growing too imperfect. In gas-fired boilers, firing must always be regulated by analysis of the waste products. Double combustion is advocated in the report, and it is shown that under favourable conditions there should be a gain in efficiency to the extent of about 8 per cent. Much information is given by the writer as to the relative merits of different types of boiler, but the various comparisons made do not show very definite results. The main point established—a point that cannot be too strongly emphasised—is, that perfect combustion is of far more importance than either the heating surface or air arrangement of a boiler.—**C. E. Strohmeyer,** *Manchester Steam Users' Association Memorandum for 1902.*

The Williams Engine.

AN engine built for the Indianapolis Light and Power Co. constitutes an example of a new type of engine, known as the Williams engine, built by the Quincy Engine Works. This particular engine is designed to develop 1,480 i.h.p., with 155 lbs. steam pressure at the throttle, running at 120 revolutions per minute, and cutting off at one-quarter stroke. It has two main bearings, with fly-wheel and generator mounted on the main shaft between them, and likewise between the main frames. Both cylinders of the engine are mounted on A-frames, with a re-heating receiver adjacent to the high-pressure cylinder. The high-pressure cylinder is steam-jacketed, and is equipped with six-ported balanced valves—four ports for steam and two for exhaust. The low-pressure cylinder is equipped with four gridiron valves, two for admission and two for release, driven by separate eccentrics, one for the steam valves and one for the exhaust, the steam eccentric being arranged in such a manner that its centre may be shifted along a line of constant lead and variable cut-off. All valves are actuated positively, but the high-pressure only are under governor control. The low-pressure gear consists of two eccentrics, and the arrangement of the eccentric rods and levers is such that the maximum velocity of valve movement is obtained at the proper point. Lateral vibration is nullified, to a great extent, by the long rod which extends from the base of the frame to the bracket carrying the horizontal shaft. The accelerated movement of the low-pressure valves is obtained by the use of two sets of rockers, by which a quick and full port opening is obtained at comparatively early cut-offs with small travel and without excessively sharp angles at the rocker arms. The high-pressure valves operate freely under two pressure plates, and the construction is such that one plate at each end of the cylinder answers for both steam and exhaust, steam being admitted from the centre and released from the ends, thoroughly separating the hot steam from the cold; and by the introduction of four ports for admission, the valves may be comparatively small. The governor consists of two weight arms controlled by two springs directly opposite each other, and is fitted with a resistance box to overcome the supersensitiveness of the governor. Regulation is brought about by shifting the eccentric across the shaft, and as a small electric motor moves sliding weights on the arms, the speed of the engine may be controlled from the switchboard. The governor wheel is mounted on the same shaft as the fly-wheel, and controls admission to the high-pressure cylinder only. A large oil-tank is located on the upper platform of the engine, and piped to the cross-head guides, crank-pins, main bearings and eccentrics, a sight feed being supplied at each outlet. Water-jackets are used on the guides and main bearings, and the oil, as it finally leaves the end of the main bearing, is taken through the crank-pins and finally thrown into the crank-pits, whence all oil is drained away for filtration.—*Power, Jan. 1903*, pp. 1-5.

Entropy.

IN this short paper Professor Poincaré takes part in the controversy on the correct definition of Entropy, showing what the mathematical basis is, and how far this basis is not quite satisfactory. His conclusions are briefly summarised thus:—(1) Entropy is a function of the co-ordinates. (2) Is not defined by the equation $d\phi = \int d H/\theta$. This equation, arising from *another* definition of entropy, can be demonstrated for reversible changes. (3) It is wrong for *all* irreversible changes, and not only for those where there is exchange of heat in the narrow sense of the word. (4) In an irreversible change in which there is no exchange of heat the entropy increases. (5) It increases, for instance, in the case of a mixture of gases, and the increase can be calculated. (6) If the universe is regarded as an isolated system, it can never come back to its original state; for its entropy is always growing, and this entropy being a function of the co-ordinates, would come back to its original value if the universe came back to its original state.—**H. Poincaré,** *Electrician, Feb. 13, 1903*, pp. 688-689.—*H.*

Notes on the de Laval Steam Turbine and Superheating of Steam by Wire-drawing.

THE author gives illustrations made from sketches and instantaneous photographs, showing the effect of the form of the nozzle of the turbine upon the form of the jet. One object of the notes here set out is to show the advantages of entropy-temperature diagrams in the treatment of problems relating to steam turbines, and to the superheating of steam by wire-drawing. By the use of these diagrams the author shows how to find the velocity with which the steam issues from a de Laval nozzle, and the thermal efficiency of the turbine. After explaining how the steam on leaving a turbine wheel has a high residual velocity, and how this exhaust steam may be superheated by the conversion of its residual kinetic energy into heat by friction, the author discusses this question of superheating by wire-drawing and shows two methods, recently devised by him, for carrying it out. — **W. H. Watkinson,** *Trans. Inst. Eng. and Shipbuilders, Scotland, Feb. 1903, Vol. XLVI.*, part V.—*H.*

Recording Apparatus for Engine Governors.

FROM the earliest days, when automatic devices were first used to regulate the speed of steam engines, attempts have been made to discuss mathematically the motions of governors. To obtain information as to the relations between speed and position and the influence of friction in governors various experiments have been made from time to time, but none of the devices in question furnish data sufficiently precise or complete to adapt the theoretical equations to practical use in designing. The author says that a device satisfactory for experimental use should show the position of the governor and the time required for any given change in position, or, what is more interesting in the study of inertia governors, the rate of change in velocity during that change in position. It should show not only the distance from centre of eccentric to centre of shaft but also the relative angular position of the eccentric with respect to the crank, and of the crank with respect to the line of dead points. It should be applicable, in one form or another, to any engine, yet of such a nature that it will not impede free motion of the gear or alter it in any way. Since changes in governor position take place so quickly, the apparatus should produce a permanent record of both position and time, and the time intervals should be marked in such a way that they may be made as short as desired. The apparatus next described by the author is said to fulfil in a measure nearly all these requirements. It produces on a strip of paper, in parallel lines so that they may be compared, an almost continuous record of the position of any part of the governor; a record of time intervals of any duration, even to a small fraction of a second; a record of the angular position of the crank, as many times in one revolution as may be desired; and an automatic record of change in load on the engine, or any other event. The records are made by electrolytic decomposition of a chemical salt absorbed by the paper which is drawn under a series of recording styles while it is still damp. The passage of a very weak current of electricity from the style produces a clearly defined mark. Chemical action only takes place while current is passing, so that if the electrical circuit is continually made and broken, the record produced is a series of short dashes. Time intervals are recorded by momentary closure of the circuit through one style by a "second" pendulum, and briefer intervals by an electrically-driven tuning-fork. The apparatus was first applied to a tandem compound engine at the Massachusetts Institute of Technology, simply to find out whether or not it could be made to work, but it has since been used for obtaining records, some of which are reproduced in this paper. It is proposed to use the apparatus for investigating the action of some form of single-weight inertia governor. These governors usually have helical springs, easy to calibrate, and the whole design is such that all the forces at work, excepting friction, can be computed analytically. Such governors can be adjusted to regulate very closely and very quickly; but although their motions are quick the recording current is quicker, and the precise position of the weight, with the direction and velocity of its motion at any instant, should not be difficult to determine. If reliable data of the actual performance of one of these governors can be obtained, perhaps the information may at last be supplied to make it possible to predict by analytical investigation the action of any governor of the same type.—**Joseph C. Riley,** *Trans. Am. Soc. Mech. E., Vol. XXIV. (Paper read at New York meeting, Dec. 1902.)*

DYNAMOS, MOTORS, Etc.

The Manufacture of Large Dynamos.

IN Part I. of this paper the writer considers details of the modern multipolar dynamo and gives various useful data. The modern practice of making the yoke with well-rounded curves has the advantage that it can be swept up with a strickle, so

saving much pattern-making. As excellent magnet-steel can now be obtained at reasonable prices and in good time, cast-steel is being largely used for quite small machines, the poles being cast solid with the yoke, so that only pole-shoes are required to complete the circuit. The modern tendency to reduce the number of armature slots in the poles calls for lamination of the pole surface, to prevent undue eddy-current loss. The bolting on of an entirely laminated pole is a somewhat awkward business, and the author describes various methods adopted in practice, as well as methods for the partial prevention of field distortion in the gap. After discussing the beneficial results obtained from cutting back the pole tips, he passes on to consider some noteworthy features of recent armature hub design. By cutting off the armature discs in a lathe fitted with bevelled cutting wheels, absolute concentricity of the holes and the periphery is insured; and any size of armature disc can be made without the expense of punching tools. Another reason for cutting armature core plates is that punching tends to increase the hysteresis loss. If varnish is used as the insulation for core-plates, it is advisable to dip the plates and pass them between rubber rolls, thus covering both sides in one operation. When the plates are large, varnish or paper pulp can be laid on with a pneumatic sprayer; and where wood-pulp paper is used, the best plan is to apply it to the sheets by the Stolberg pasting machine. The author believes that the tendency of the future in respect of slots will be to follow traction-motor design, and that the number of slots for a given diameter of core will be much reduced. Barrel-winding shows to great advantage when applied to the armatures of multipolar dynamos, as the larger the diameter and the greater the number of poles the less in proportion is the space taken up by the diagonal end connections. The writer thinks it would be well to bend the conductors by means of levers shod with rollers, and that it would be better to bend them at one end only. In this way a conductor could be slipped through the micanite tube from one end of the tunnel, and the present wedges and bindings be done away with altogether. The writer further suggests that one end of the conductors be held against centrifugal force by the end ring, and the other end by the upright of the commutator segment, bent over and riveted. Referring to internal currents, the author says that recent Westinghouse machines have special conductors at the bottom of some of the slots, which are said to prevent surging of the magnetism in the field circuit, and describes an ingenious method adopted by the New England Motor Co. for equalising the magnetic circuit. Multiplex armature winding also is useful for the reduction of eddy-current loss. A feature which many dynamos lack is gear for raising and depressing the brushes all together, and, as the author suggests, this could be arranged by means of bell-crank levers at the ends of the brush spindles. For electrical insulation mica is better than all other materials in that it has high disruptive strength, and is not affected by atmospheric conditions. Shellac varnish has been more used than any other, but quality varies so much that other varnishes, as well as paints and linseed oil, are largely employed. An easy way to varnish an armature is to pour the varnish, or whatever is used, into a shallow bath and to support the armature in journals, so that its periphery just dips into the liquid. By revolving slowly brushes can be dispensed with altogether. The author describes various methods of series winding, and in speaking of shunt-windings says that as each pole should have the same magnetic strength, it is necessary to get the right quantity of each size wire on each pole. The energy stored in the magnetic circuits of large dynamos is so considerable that it is well to make a short-circuiting shunt-brake switch part of the machine. The Passburg vacuum apparatus for baking is the best known, and has been adopted by the leading Continental firms. There are many advantages to be derived from its use, not the least of which is that an armature or coil may be thoroughly dried in a couple of hours which would take 12 hours in an oven. In Part II. of his paper the author deals in a somewhat similar manner with multiphase alternators, among the chief points considered being the following: Typical designs, air-gap, inner-pole machines, cyclic irregularity, and voltage drop. Eight tables which accompany the paper serve to collect a great deal of useful information with regard to the types of machines discussed.—**E. Kilburn Scott,** *Trans. I. E. E., Jan. 1903.* (*Paper read Jan. 8, 1903.*)

Series Motors with Simple Alternating Currents.

A MATHEMATICAL analysis of the conditions of operation of these motors and a comparison with the continuous-current series motor. The comparison of the two sets of equations shows the complete analogy between the properties of the two types of motor when the brushes are fixed at right angles to the resultant flux. The general case in which the direction of the armature flux makes an angle θ with that of the resultant

flux is also considered. — **P. Girault,** *L'Industrie Electrique, Feb. 1903,* pp. 31–36—*H.*

BATTERIES, ACCUMULATORS, AND ELECTRO-CHEMISTRY.

Capacity of Lead Storage Battery.

THE theoretical capacity of the positive active material, lead peroxide, is 101·8 amp.-hrs. per lb. By practical tests on an ordinary commercial cell designed for automobile use, the author found a total capacity, for a very low rate of discharge, 11 amp. constant for 24¾ hrs., of 272·25 amp.-hrs. At a 4-hr. discharge rate the same cell gave 200 amp.-hrs. The total positive active material in the cell was 6·25 lbs., which at 101·8 amp.-hrs. per lb., should give theoretically 636·25 amp.-hrs. The actual capacities, then, were for low rate of discharge 42·8 per cent., and for high rate 31·4 per cent. of the theoretical. Assuming Wade's hypothesis to be correct, the ideal amp.-hr. capacity of PbO_2 is reduced to half the value given above, so that the practical capacities obtained become respectively 86 and 63 per cent. of the possible. The problem then is to secure for high rates of discharge as high an efficiency as that for low discharge rates. The best way to accomplish this result is to make the active material more readily available to voltaic action by increasing its porosity. Mechanical strength, combined with porosity, ought to give efficient discharges at high rates and at the same time greatly increase the life of the battery. These conditions may possibly be realised for PbO_2, though the nature of that substance may make the solution somewhat difficult. The author touches briefly on the question of the weight of the cell, points out the difficulties in the way of reduction of the dead-weight, and indicates that the chief possibility for the improvement of the lead cell lies in the active material.—**A. L. Marsh,** *Electrical World* (N.Y.), *Feb. 14, 1903,* pp. 271–272.—*H.*

Theory of Electrolytic Dissociation.

THE theory of electrolytic dissociation, due principally to Arrhenius, was applied with such satisfactory results to aqueous solutions that its general, though not universal, adoption immediately followed. Of late, however, evidence has been offered to show that the general connection between the properties of electrolytes, which seems to exist in the case of solutions in water, fails when other solvents are used, and that the exact numerical relations given by theory are inexact at moderate concentrations even for aqueous solutions. In this paper the author discusses at considerable length the foundations on which the theory rests, and inquires how far they are affected by the later criticisms just indicated. Having arrived at definite conclusions from theoretical considerations as to the relationship between the osmotic properties and the electrical conductivity, the author examines how far the experimental facts bear out these theoretical conclusions, and finds that, in those cases for which the theory indicates exact relations, the experimental evidence is in favour of their existence, while all discrepancies are either suggested by the theory itself or else occur under conditions where the experimental knowledge is too fragmentary for valid conclusions to be drawn. The author considers also some other deductions from theory, which have been criticised of late, and accounts for their apparent failure when applied to special cases.—**W. C. D. Whetham,** *Phil. Mag., Feb 1903,* pp. 279–290.—*H.*

The Accumulator.

THE second article of a series, of which No. 1 was noticed in our March issue. In this paper the author studies further the essentials of the accumulator, paying special attention to Faraday's law correlating the weight of substance deposited and the energy spent in carrying out the electro-chemical reactions. — **J. Izart,** *L'Electricien, Feb. 7, 1903,* pp. 86–88.—*H.*

TRACTION.

Three-Cylinder Compound Passenger Locomotives on Midland Railway

IN this paper an exhaustive description is given of the new type of three-cylinder passenger locomotive, lately introduced on the Midland Railway by Mr. S. W. Johnson, Locomotive Superintendent, to deal with the heaviest express traffic. Sectional drawings, tables of dimensions, and indicator diagrams for actual runs, are given. The high-pressure cylinder, diameter 19 ins., stroke 16 ins., is placed between the frames under the smoke-box, and communicates its power to a central crank on the driving-axle. The low-pressure cylinders, 21 ins. diameter, 26 ins. stroke, are placed outside the frames on either side of the high-pressure cylinder, and drive crank-pins on the wheels at the ends of the axle connected to the high-pressure cylinder. These cranks are at right-angles to each other, while the middle crank bisects the angle between them. The middle cylinder takes steam directly from the boiler at 195 lbs. per sq. in., and exhausts it, without

the intervention of any pipe, directly into the steam-chest common to the outside cylinders. Simultaneously with the admission of steam to the high-pressure steam-chest, steam is automatically admitted to the low-pressure steam-chest by a specially constructed regulating valve, placed on the side of the smoke-box. When the maximum pressure allowed for the low-pressure steam-chest is attained, this valve cuts off further supply of steam from the boiler. A controlling valve in the cab governs the amount of steam that can be passed by the regulating valve between the minimum and maximum limits. The other special features of the engine are given in the article. These engines are working express trains between Leeds and Carlisle, and have given excellent results in regard to speed, starting, rapid acceleration of speed, and economy in fuel and water.—*Engineering*, *Feb. 6, 1903*, pp. 170-176.—*H.*

Electric Automobiles.

THESE have now become thoroughly practical vehicles, journeys of over 100 miles on one charge, and tours of over 1,000 miles (from London to Glasgow and back) having been satisfactorily accomplished. Electrical energy gives rise to no noise or smell, makes no refuse, and is convenient. It also affords facilities for braking power and recuperation of energy which are not obtained with other sources of energy. Tabulated examples of recent long-distance runs of carriages propelled by one charge are given by the author, and these records are analysed for comparison, elevations and plans of the carriages being shown to scale, and the disposition of the batteries indicated. The author then considers the leading points in connection with the various parts of an electric automobile, namely, the storage-batteries, or accumulators, motors and gearing controllers and circuits ; underframes, types of vehicles, design and construction of carriage and proportion of power to load ; as well as the comparative cost of electric and other motor cars. A battery of accumulators weighing 6 cwts. gives 10 h.p.-hours, or 67·2 lbs. weight of battery for 1 h.p.-hour, taking the efficiency of the motor and gear at 75 per cent. Assuming an output of watt-hours for 1 lb. of complete battery, such a battery would convey itself against a tractive resistance of 50 lbs. per ton (or 1/45) at the rate of 12 miles per hour, for a total distance of 250 miles. If the vehicle to convey this battery weighed 6 cwts., the distance that could be run with vehicle and battery would be 125 miles ; and with a load of 3 cwts. (driver and passenger) the distance would under the same conditions be reduced to 100 miles, equal to 75 ton-miles. With twice the load, or 6 cwts., the distance of the run would be reduced 83·8 miles, but the ton-mileage would be the same ; and with three times the load, namely, 9 cwts., the distance would be still further reduced to 71·4, also equal to 75 ton-miles. The cost of carrying the useful load would be, for the 3-cwt. load, at the rate of 1·8*d.* per ton-mile ; for the 6-cwt. load, 1·1*d.* per ton-mile ; and for the 9-cwt. load, 0·9*d.* per ton-mile. Curves are given in the paper showing the ton-mileage, in conjunction with the ratio of weight of battery to the total weight ; the ratio of useful load, to the total weight : the cost of electric energy per ton-mile of useful load, the cost of electric energy for running the car and battery with and without load ; also the relative weights and costs of cars.—**H. F. Joel,** *Proc. Inst. C. E., Session 1902-3.* No. 5.

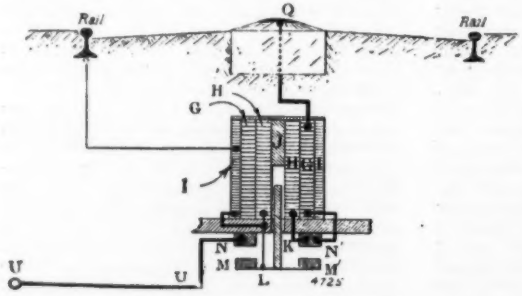
The Essentials of a Good Draft Gear.

HAVING stated that the draft gear of a car is composed of the drawbar, the yielding portion, and the attachments to the car, the author considers the essentials which should always be present in such devices. Draft gear, more than any other part of the car structure, is subjected to severe shocks and stresses both of tension and compression ; therefore great strength is of importance. A designer should make the drawbar of the strongest possible material, see that its attachments are of the proper cross-section to withstand fully as great stresses as the bar, and that they are secured to the car framing firmly with bolts, keys, and other accessories arranged to distribute the stresses as advantageously as possible. Such a design would leave out entirely the second, or yielding, portion of the draft gear, because it is much easier to attach a drawbar to the car framing directly than by interposing a spring, or other yielding member, between the drawbar and the car. But the pulling and pushing strains imposed on the drawbar are not gradually applied, but generally come as shocks or blows. It is, therefore, clear that another essential of a good draft gear is interposed yielding resistance. The enormous weights of modern cars and locomotives give to these bodies, when once set in motion, a capacity to exert strains and stresses in their draft gear far greater than the tractive power of the most powerful locomotive. In fact, the weights of modern cars and locomotives are so great that unless the speed with which they come together is moderate, no draft appliance can withstand the shock, even when the greatest possible amount of yielding resistance is interposed. The yielding portion is so essential that

without it no draft gear could long endure; and it is evident that the amount of yielding resistance formerly adequate is entirely inadequate with the heavier cars and locomotives now used. It is also essential not only that the yielding portion of the draft gear be of large capacity, but that it should have little reaction or recoil. Now, having the strongest possible drawbar, properly arranged with an adequate amount of yielding resistance with minimum recoil, the third, or fixed, portion of the draft gear should be of the strongest available materials, and secured to the sills of the car in such a way as to bring the heavy strains of pulling, and the still heavier buffing stresses, upon the parts of the car best adapted to receive them. The disposition of the attachments so that the various stresses come on those parts of the car which can best resist them is the great essential. It is also necessary that the draft gear attachments, or the so-called fixed portion, should be so designed as to admit of proper inspection and facility in making repairs or renewals. The essentials of a good draft-gear, therefore, are—(1) A drawbar of the strongest material to resist blows, jerks, etc., with secure attachments to transmit stresses received; (2) adequate yielding resistance with minimum recoil, securely housed; and (3) fixed attachments to the car, strong and well-designed for ease of inspection of the gear, and well secured to the car so as to distribute and dispose of all stresses as advantageously as possible.—**E. M. Herr,** *The Railroad Gazette, Jan. 2, 1903*, p. 2.

The Ramassot Surface-Contact System of Electric Traction.

In this paper the author describes the leading features of the Ramassot surface-contact system, whose chief characteristic is that the street contacts are absolutely independent of each other, and that the mechanisms actuating these contacts can be placed in groups in proper receptacles under the footpath and far removed from the track. The figure reproduced shows the equipment for a street contact. The plot *Q* is connected to one coil, *G*, of a solenoid having three coils, *G*, *H*, *I*. The winding of *G* is sufficiently large in section to take the normal motor current; *H* has a finer winding, whose purpose is to supply the necessary ampère-turns to actuate the mechanism; while the *I*-winding represents a resistance of about 1000 ohms to regulate the current in the *H*-winding, when the apparatus is in use. The three coils are connected in series. The solenoid has two cores, one, *J*, fixed, the other, *K*, movable, and carrying a cross-piece *L*, with two carbon contacts *M*, *M'*. When *K* is lifted into the coil, *M* and *M'* come into contact with other two carbon terminals *N*, *N'* on the porcelain base-plate of the solenoid, and, as will be seen from the figure, the coil *G* is then connected up to the cable *U*, carrying the main current, which is thus free to pass to the motors, the circuit being completed as usual by the rails. At the same time *H*, which has one terminal permanently connected to *L*, is short-circuited, so that the core *K* is free to fall and re-establish the original conditions as soon as the car-skate has left the preceding plot—that is, at the moment when the skate has just arrived at the plot next in succession. For the energising of the coil *H* to lift the core *K*, it is obviously only necessary to establish a suitable difference of potential between the plot and the rail. This may be supplied from the line and the circuit closed by the preceding plot, or it may be produced by a battery carried on the car. Plots are placed every 5 metres along the track, and these distributing mechanisms, collected in groups of 10, 15, or 20, are placed in receptacles under the pavement at every 50, 75, or 100 metres. The figure shows that the only connection between *Q* and the distributor is a simple cable, and as this may be of any length, it is possible to remove the distributors far from the track and group them together in this convenient way. The trials made on lines equipped with this system have given satisfactory results, and there is reason to believe that these will hold good in extensive operation if the distributing apparatus maintains its insulation.—**A. Bainville,** *L'Electricien, Feb. 28, 1903*, pp. 129-131.—*H.*



THE RAMASSOT SURFACE-CONTACT SYSTEM.

LIGHTING AND HEATING.

The Future of Coal Gas and Allied Illuminants. (Cantor Lectures.)

LECTURE I. deals with the radical changes which have fallen to the lot of gas manufacture during the past twenty years, showing also the beneficial influence of good burners from the gas consumer's point of view. Coal gas is said to be daily used more and more as a fuel; and the lecturer considers that the future of coal gas is entirely dependent upon a plentiful supply of low-grade gas, having an illuminating value of 10—12 candles, and a heating value as high as can be practically attained. The method of obtaining a low-grade gas, which would be most welcome to the gas-manager, would be to make the gas as heretofore and to dilute it down to the required point. In Great Britain water gas is almost entirely used to enrich and augment the supply of coal gas, the percentage of carburetted water gas so added varying between 20 and 50 per cent. Referring to CO as a constituent of blue water gas, the lecturer says his own view is that practical safety is assured so long as the proportion of carbon monoxide in the gas supply does not exceed 16 to 17 per cent. In Lecture II. is discussed the manner in which the type of gas needed in the future may best be obtained. Having considered the effects that may be expected from high temperatures in carbonisation, the lecturer proceeds to discuss the effect of blue water gas as an economical diluent, taking as a dominating factor that not more than 40 to 43 volumes must be added to 100 volumes of coal gas, for fear of raising the percentage of CO in the mixed fuses above the advisable limit, and also because directly that limit is exceeded carbon monoxide begins to interfere with the action of atmospheric burners, and tends to cause flushing back. The lecturer thinks the time has now arrived when, in devising parliamentary requirements, a standard of calorific value should also be introduced. In the third lecture of this series the lecturer shows that the alterations which are now taking place in the conditions under which coal gas may be used for illumination are almost entirely dependent upon the adoption of the incandescent mantle as a means of developing light. The characteristics of incandescent lighting and the various theories put forward to explain the wonderful light emissivity of the mantle are discussed in some detail. Another direction in which the future of coal gas will benefit largely by a cheapening in price, owing to economies in manufacture and distribution, is said to be in its use as a fuel. The gas companies have it in their power to govern the gas-stove trade, and unless they take the initiative the popularity of heating by gas will be retarded to a most serious degree. Improvements in gas motors and gas engines are steadily going on, and as soon as the price of coal gas can be reduced sufficiently to attract this class of custom a wide field will be opened up for it. "Allied illuminants" form the subject of the concluding lecture: and under this heading are treated mineral oils, distilled and natural oil gases, air carburetted with the vapour of petroleum, and acetylene gas, used alone and with oxygen.—**Professor Vivian B. Lewes,** *Journ. Soc. Arts, Dec. 26, 1902,* and *Jan. 2, 9, 16, 1903.*

The Mercury Arc.

THE author has been, and still is, carrying on an investigation of arcs and arc spectra, and in this paper he gives a short review of the work relating to the mercury arc. The great difficulty found in using this light is the starting of the arc. The common method is to bring the terminals together and then separate them when the arc is struck; but this is impracticable with an arc several feet in length. Some investigators have used high voltage discharges as starting devices; but for general use this method is also impracticable, since it practically precludes the use of the mercury arc in series connection, for which, owing to its low voltage, it is eminently suitable. The difficulty has been overcome by an ingenious device developed by Dr. Weintraub of the General Electric Company, and described by the author. The tube contains a small auxiliary arc by means of which the main arc is started without any increase of voltage over that at which it operates normally. The mercury arc is found to be the most stable of all the arcs. It is unlike the carbon arc in that, with constant arc length, the voltage is constant irrespective of the current. It is very little sensitive to wide variations of voltage and current. The author's laboratory and conservatory are lighted by a number of mercury arcs in series connection which derive the power from the trolley circuit at the end of a long branch line, where the voltage varies excessively during the time of heavy traffic—5 to 7 p.m.—fluctuating between 280 volts and 600 volts, while the current varies between 2·5 and 8 amp. in the mercury arcs, without causing serious difficulties. The efficiency of the mercury arc is about two to three times that of the carbon arc, and four to six times that of the incandescent or Nernst lamp; and it does not vary materially with the current, so that the mercury arc provides an electric light which can be turned up or

down without loss of efficiency. The most prominent feature of this light is its bluish-green colour, which gives the mercury arc a distinctive field of its own. The harmful physiological effects of light disappear on exclusion of the red rays, and the mercury arc is therefore the only known artificial illuminant, which is perfectly harmless. It is especially suitable for use in drawing-offices, factories, or generally places where accurate work has to be done by artificial light. It gives specially brilliant effects wherever green is the preponderating colour, and is thus best suited for suburban street lighting, lighting of country seats, greenhouses, etc. All vegetation takes on a specially vivid and fresh appearance under this light, and its high actinic character gives a fluorescent sheen to many substances usually not recognised as fluorescent, such as glass, snow, etc. For indoor illumination the mercury arc is not well suited unless the red and orange rays are added; but this lowers its efficiency. The mercury arc can be used on alternating as well as on direct current circuits. In an alternating-current circuit the current through the arc is unidirectional, so that any apparatus connected into an alternating-current circuit through a mercury arc, receives a uni directional current and the arc acts as a rectifier. This feature is of interest in connection with the transmission of power.—**C. P. Steinmetz,** *Electrical World* (N.Y.), *Feb. 21, 1903*, pp. 316–317.—*H.*

TABLE I.

Working Load for Manilla Rope.

A	*B.*	*C.*	*D.*	*E.*	*F.*	*G.*	*H.*
Diameter of Rope.	Ultimate Strength.	Working Load in Pounds.			Minimum Diameter of Sheaves in Inches.		
Inches.	Pounds.	Rapid.	Medium.	Slow.	Rapid.	Medium.	Slow.
1	7,100	200	400	1,000	40	12	8
1¼	9,000	250	500	1,250	45	13	9
1½	11,000	300	600	1,500	50	14	10
1¾	13,400	380	750	1,900	55	15	11
1⅞	15,800	450	900	2,200	60	16	12
1⅝	18,800	530	1,100	2,600	65	17	13
1¾	21,800	620	1,250	3,000	70	18	14

POWER AND TRANSMISSION.

Working Loads for Manilla Rope.

THE writer gives the results of an extended experience, together with some examples of the life of rope in actual use, which will be a guide to engineers in judging what service can reasonably be expected in similar cases. The ultimate strength given in Table I. is materially affected by the age and condition of a rope in active service, and also it is said to be the fact that rope is weaker when it is wet. It has been said that a few months of exposed work weakens rope 20 to 50 per cent. The ultimate strength of a new rope given in column *B* is the result of tests made of full-sized specimens of manilla rope, purchased in the open market, and made by three independent rope walks. The author says that the Table can be depended on as a reliable and safe guide in estimating the factor of safety for any case in hand. The proper diameter for pulley-block sheaves for different classes of work, given in columns *F*, *G*, and *H*, is a compromise of the various factors affecting the case. An increase in the diameter of sheave will materially increase the life of a rope. The advantage, however, is lost by increased difficulty of installation, a clumsiness in handling, and an increase in first cost. It can safely be assumed that the best size is one that balances the advantages and the drawbacks as they are found in practical use, and makes a fair balance between the conflicting elements of the problem. It would be rash for anyone to attempt to make a decision from theoretical considerations; but an average of the practice of a large number of users, furnishes an acceptable basis for a decision as to the limits of good engineering practice. That average the table aims to give. It will be understood that a table of working loads must be a general one, covering ordinary cases arising in practice. Local conditions may be such as to make it advisable to vary from the stresses given in the tables. In cases of great importance an engineer should carefully investigate the subject in detail, and then decide upon the exact stresses that he will put on his tackle, but ordinary cases are fully covered by the data given.—**C. W. Hunt,** *Iron and Coal Trades' Rev., Jan. 16, 1903*, p. 139.

Electric Lifting Magnets.

THE absence of electric power in workshops and yards of moderate size has in the past retarded the general introduction of electric lifting magnets as time-saving devices, but they are now in use in connection with cranes and other types of conveyors in many large works. The greatest field for their use is, of course, in the handling of iron or steel, which are magnetic materials, but by the adoption of proper iron cradles almost any other material may be conveniently lifted and transported by the magnets. Excellent results are obtained in moving of bulky goods by using two or three magnets in conjunction; by this means rolling mill steel plates 42 ft. long, 8 ft. wide, and ½ in. thick have been easily moved and at a time when they are so hot that manipulation by chains would be very difficult and dangerous. Each magnet displaces a gang of from 6 to 12 labourers. The designs of these lifting magnets vary considerably, but the most popular form is a simple horse-shoe with one limb so developed as to form an envelope for the rest of the magnet; but this type is not very suitable for such work as plate-lifting on account of the shape of the pole face and the excessive leakage from pole to pole. Experiments made to find the best designs produced some curious results. For example, a round magnet lifting easily 5 tons on straight pull could not pick up a long plate weighing only half a ton. For plate-handling the form now usually adopted has a group of rectangular poles. The author gives some instances of the lifting power of different types of magnet. At the Illinois Steel Company the favourite type has a pole-piece of 5 ins. cross-section and 3½ ins. length with the coils surrounded to a depth of ¾ in. The magnet face is rectangular in form. The weight of this magnet is 300lbs., and in a test has been made to lift four tons. It can be operated with four ampères at 230 volts, or 920 watts, but usually takes 4·4 ampères at 250 volts, or 1,100 watts.—**W. Fawcett,** *Electrical Review (N.Y.), Jan. 31, 1903,* pp. 163-64.—*H.*

TOOLS AND WORKSHOP PRACTICE.

Cutting Angles of Tools.

ONE of the first elements governing the speed and feed of cutting tools for metal work is that relating to the individual and combined angles of the tools themselves. What a tool will do, and the angles it requires, will be found to depend upon: (1) the material of which it is made; (2) upon the nature of the material to be cut; (3) upon the speed it is desired to work at; (4) the depth of cut; and (5) the feed. In the experiments quoted, the tools were all either of ordinary self-hardening steel or ordinary tool-steel, and the materials cut were such as were in daily use in the shops in which the tests were conducted. These materials have varying degrees of hardness, and for purposes of comparison Tables are given in which are set out the chemical analyses or the leading features thereof, and the mechanical tests for each specimen. Variation in the tool angles is always dependent on the nature and hardness of the material to be cut, but the influence of the depth of cut and the fineness or coarseness of the feed must not be overlooked. Experience during the investigations mentioned shows that a heavy cut and slow speed is more efficient than a light cut and quick speed. The experiments covered fourteen different qualities of materials, of which seven were steel, one wrought-iron, one cast-iron, and five yellow-metal alloys of different degrees of hardness and chemical constitution. The angles of the cutting edges of tools ranged from 57½° to 75°. Experience indicates that the clearance angles should under no circumstances be less than 3°, and that they should be greater as the diameter of the work in the lathe increases. The experiments were all made with pointed roughing tools, though in some cases the point was somewhat rounded off. During the course of the experiments it was thought desirable to secure data with regard to the weight brought to bear upon the point of the tool when cutting, and the device worked out for this purpose is described. The tests indicate that when working with a high speed of material, a light cut, and a fine feed, different angles are required to those found most suitable for a heavier cut, a slower speed of material, and a coarser feed. The ruling factor in fixing cutting angles must in all cases depend, to a very large extent, upon the hardness of the metal to be cut; the harder the metal, the more obtuse will be the angles of the tools. Softer material clearly requires the sharper angle of tool, but for purposes of finish the feed is rather finer, and this supports the suggestion that the variations in the angles are closely allied to speed and feed. Further, the possibilities of speed of working on hard, medium, and soft material rise in accordance with the nature of the material. The information gathered from these investigations has tended to assist in the consideration of more than one subject connected with shop administration, with, as the author believes, very beneficial results.—**H. F. Donaldson,** *Paper read at the I. Mech. E., Jan. 1903.*

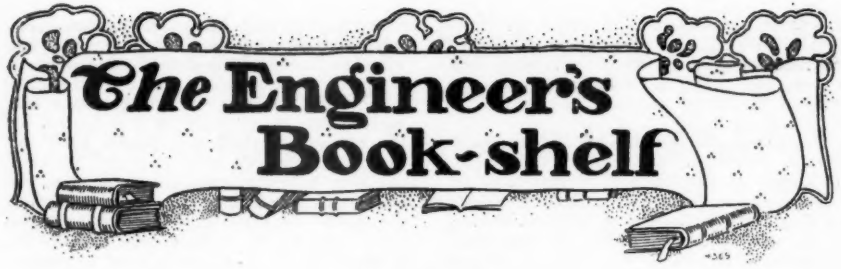
MISCELLANEOUS.

The Stability of Sewage Effluents.

ORGANIC matter may be in such a condition that bacteria change it easily, or it may be they can change it but slowly. Most of the organic matter present in sewage is illustrative of the first condition, and that present in soil and loam is illustrative of the second. One of the objects of this paper is to show that organic matter of the first class can be so changed by bacterial agencies as to take its place in the second class; that this change can occur in filters operated at high rates; and that this matter, when changed to a more or less stable condition, can safely remain in the effluent instead of being strained or filtered from it. At an experimental station mentioned by the author, it was observed for a number of years that very turbid effluents from filters of coarse materials, operated at high rates of filtration, would often remain without change for an indefinite time, and that the suspended matter in the effluents from these filters was apparently in a stable condition, quite different from the condition of the putrefying, ill-smelling matters in suspension in the sewage itself. It is evident from a study of all the results obtained, that the amount of organic matter determined as albuminoid ammonia and oxygen consumed in the effluent of a sewage filter constructed of coarse material, and operated at a high rate of filtration, is not a true index of the degree of purification of such an effluent, if we mean by purification the oxidation in the filter of the organic matter of the sewage to a more or less stable condition, and the production of an effluent which will not putrefy when having free access to the air. In order that such a stable effluent may be produced, it is only necessary that sewage shall have been for a comparatively short period of time in thin layers in contact with an abundance of air, and that aërobic bacterial life shall have been active without the added straining out of organic matter obtained by sand or other filters of fine material. Such an effluent will show good nitrification, and the presence of dissolved oxygen when running from the filter, irrespective of the amount of stable organic matter that it contains. These effluents, produced either by intermittent-continuous filters or by the best of contact filters, show little tendency to change when excluding air, and maintained at summer temperature for a considerable period. The investigations made by the author seem to throw some doubt upon the significance of the so-called five-day incubation test, with the determination of oxygen consumed only, used to determine the stability or instability of the organic matter of the effluents of sewage filters, that is, to determine their liability to undergo the so-called secondary decomposition. This determination is very much depended upon in England, to show the character of the effluents of sewage filters, as being a much shorter way than complete analyses of these effluents. It would seem, however, that in most instances a determination of the dissolved oxygen present, at the beginning and the end of the period of incubation, together with observations of the change in appearance of the sample, would be a more satisfactory and simpler test.—*The Eng. Record, Dec. 27, 1902*, pp. 611-612.

Rotary Pumps.

AFTER a careful study and analysis of the different forms shown in the United States Patent Office Records, and in Prof. Reuleux's "Kinematics of Machinery," and also of those which were on the market at that time, the writer decided, about ten years ago, that a rotary pump having two similar impellers, the contours of which were formed by complete epi- and hypo-cycloids, would make a machine that would give excellent results if properly constructed and applied. The displacement per revolution of a two-lobe cycloidal pump is exactly the volume of the cylinder in which the impellers revolve, or, in other words, the area of a two-lobe cycloidal impeller is one-half the area of the circumscribed circle. This fact makes it possible for this form to be used as a meter, the displacement of which can be very accurately determined, the discharge from the pump being continuous but not uniform. The action of a rotary pump or blower as an air compressor is practically the same as the action of a duplex, crank-and-fly-wheel, double-acting, piston compressor which has mechanically operated valves opening and closing at the beginning and end of the stroke, assuming the piston machine to have no clearance spaces. There is, therefore, no gradual compressing of air in a rotary machine, and the unbalanced areas of the impellers are working against the full difference of pressure at all times. The proper application of rotary positive machines when operating in air or gas under differences of pressures from eight ounces to five pounds is where constant quantities of fluid are required to be delivered against a variable resistance, or where a constant pressure is required and the volume is variable.—**J. T. Wilkin,** *Proc. Am. Soc. Mech. E., Dec. 1902, Vol. xxiv.*



Modern Gas and Oil Engines.—By Fredk. Grover, A.M.Inst.C.E., M.I.Mech.E. 3rd Edition. 1902. (The Technical Publishing Co., Ltd., Manchester.)

In this edition the author has further added to the success of his previous endeavours to help the mechanical draughtsman in applying his art to the design of gas engines. That no essential practical or theoretical requirements have been omitted will be evidenced by the following brief review of Mr. Grover's work.

After an introduction relating to the history of the gas engine, we find a concise description of a gas-engine plant, which deals with the most suitable arrangement of the engine room, and some hints upon the prevention of the transmission of vibration through the building. Chapters III., IV., and V. are occupied with a general review of modern gas engines. The types made by several leading British firms are described, with due attention to the cycle of operations in each case, to the general design, and to various details. These three chapters are well illustrated by perspective and sectional drawings, and by indicator and other diagrams. After Chapter VI., on "Self-starters," the review of modern gas engines is resumed in Chapter VII., where features of interest exhibited by other British types, including two-cycle and other engines, are briefly touched upon. In Chapter VIII. some of the leading forms of French and German gas engines receive passing and somewhat inadequate mention. Considering the importance that is properly attached to gas-engine tests in the present day, it is satisfactory to find so adequate a consideration of the whole subject in the treatise under review. This portion of the work, Chapters IX. to XVI., details the apparatus and the calculations necessary for complete gas-engine trials, and affords information generally useful in connection with such investigations. The chapters in question relate to the following divisions of the subject:—brakes, indicators, reducing gears, water and gas measurement, the analysis of coal-gas, calculations for working out results, calculations on the indicator diagram, and calculations of temperature and loss of heat. It is assumed by the author that the arrangement of the gas engine, as described in earlier chapters, is already familiar to the reader, therefore the subject of "Gas Engine Design" is treated somewhat briefly in Chapter XVII., the chief details discussed being the design of cylinders, crank-shafts, fly-wheels, connecting rods, and piston pins. The generation and application of producer gas to internal combustion engines, the utilisation of blast-furnace gases, and a consideration of the effects of the products of combustion upon explosive mixtures of coal-gas and air formerly concluded the first part of the treatise, but we are pleased to see that it now includes chapters on acetylene gas for motive power, gas-engine efficiency, and the application of entropy charts to gas engines.

Part II. is devoted to "Petroleum Engines," and, considering the growing importance of such motors, it must be said that more space might have been allotted to them by the author. Chapter XXIII. deals with the physical properties of petroleum, and traces the evolution of the oil engine. The next two chapters describe the general features and details of nearly all the stationary types of oil engine, and the following chapter is nominally upon "Oil-gas Engines," but really the title should be "Daimler Motors," for no other type is mentioned. As the method of testing gas engines applies largely to oil engines, the subject receives, in the second part of the treatise, only such attention as relates to special points in connection with the use of oil. Mr. Grover's treatise is not so voluminous as some other works of

the same nature, but in its way it is equally serviceable, and may confidently be recommended to anyone desiring reliable and thoroughly practical information on the subject of internal combustion motors.

Elementary Applied Mechanics.—By T. Alexander, C.E., M.Inst.C.E.I., etc., Professor of Engineering, Trinity College, Dublin, and A. W. Thomson, D.Sc., Professor of Engineering, College of Science, Poona. 1902. 575 pp. with numerous diagrams. London: Macmillan & Co., Ltd. Price 21*s.*

This work is a second edition in one volume of the two volumes on the subject which the authors published in 1880 and 1883, the first by Professor Alexander alone, the second by the two authors in co-operation. In the present edition the division of the subject into two parts is abolished, and there is nothing now to show that any portion of the work is due to one author alone; it is throughout a joint production. The contents of the original volumes have been re-arranged and important additional matter introduced. In a theoretical discussion of the principles of applied mechanics it is necessary to use mathematics, but there is nothing in this volume to cause difficulty to anyone who has a fair knowledge of that subject, and without such knowledge the student cannot hope to go far in theory. The book is divided into twenty-two short chapters, each dealing with a special problem—*e.g.* simple stresses and strains, transverse stresses, bending moments and shearing forces for fixed loads and for moving loads, resistance to bending and shearing at the various cross-sections of framed girders and of solid beams, skeleton sections for beams and struts, the steel arched girder, and the scientific design of masonry arches. The treatment of this last subject—the design of masonry arches—deserves special mention, as the authors have succeeded in simplifying the mathematical treatment usually adopted (necessarily somewhat complex and not lending itself readily to practical application) by using graphics, and the practical value of the chapter is increased by the addition of elaborate tables giving the information necessary for the design of segmental masonry arches. Throughout the volume the practical application of the results derived from theoretical considerations is strongly emphasised by examples worked out, while others are left for the reader to work out for himself. By this means the practical man is made to feel the value of what he is studying, for at every step he finds himself using his newly-gained knowledge in some problem which may occur in his regular work. The diagrams are excellent and help to explain the text. An intelligent student will find this a very readable book, and a useful guide if he is required to deal with practical problems within this subject. In an Appendix the authors give the solution of a roof truss by the method of reciprocal figures, both for the case in which only one end is fixed (treating here the question of the wind on the free end) and for that in which both ends are fixed. Another Appendix consists of a plate showing the cross-section of a built-earth reservoir dam, and also of a bridge, illustrating the fall in water-level due to the increased velocity resulting from the contraction of channel between the piers. Much skill and painstaking labour have been devoted to the preparation of this volume, and it deserves to be read and studied by students of engineering. The publishers have done their part, as usual, in a highly satisfactory fashion.

The Elements of Machine Design: Part II. W. Cathorne Unwin, F.R.S. New Edition. (London: Longmans, Green & Co., 1902.) 6*s.*

In this revised and enlarged edition of his well-known treatise, Professor Unwin deals largely with the details of steam engine design, and he has apparently taken a considerable amount of trouble to bring the work thoroughly up to date. Therefore in its present form it embodies the most recent practice and researches, and is admirably adapted as a reference-book for draughtsmen, and a text-book for students. Even to those who may have no occasion to design steam engines, the work will prove of considerable service, as there is much that is generally useful in connection with the design of pipes, pipe joints, valves, cocks, and lubricators of different kinds.

Coal-Cutting by Machinery. By Sydney F. Walker, A.M.I.C.E. (London: *The Colliery Guardian* Co., 1902.)

The subject taken up by the author is one of much importance to the nation at large, and we agree with his remarks as to the singular stupidity of the British coal-miner in opposing the introduction of such useful mechanical appliances as are described in this volume. Mr. Walker gives a very good historical account of mining appliances, and his subsequent treatment of modern machinery ought to be of considerable service to the colliery owner and manager. It would be of even more service to the men if they could be persuaded to read and think over its contents.